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Appendix C: Petroleum Reduction Options (Task 3)

FINAL STAFF REPORT

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Disclaimer

This technical appendix was prepared by the staff of the California Energy Commission and California Air Resources Board. This appendix is a compilation of the results based on technical staff analyses of the status of technologies, their relative petroleum reduction impacts, and costs. The report presents a range of possible costs and impacts from an illustrative group of options. The cost and benefit calculations contained in these analyses do not yet account for environmental impacts (which are included in a separate appendix). These results should not be construed as indicating policy preference for a particular technology or strategy.

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INTRODUCTION

Overview

Assembly Bill 2076 (Shelley, Chapter 936, Statutes of 2000) requires the California Energy Commission and the California Air Resources Board (ARB) to develop and submit a strategy to the Legislature to reduce petroleum dependence in California. The statute requires the strategy to include goals for reducing the rate of growth in the demand for petroleum fuels. Options to be considered include increasing transportation energy efficiency and using non-petroleum fuels and advanced transportation technologies including alternative fueled vehicles and hybrid vehicles.

The Energy Commission and the ARB have developed a process to evaluate and analyze these possible options. The goal of this effort is to provide policy makers with a robust analysis of the possible measures that could be implemented to meet the fuel demands of consumers and industry. This analysis needs to account for the costs of these measures as well as the benefits. The overall effort is guided by consultant services provided by TIAX, LLC.

This work has been divided into four tasks and assigned to the appropriate agency staff.

Task 1: The objective of the first task, led by the ARB, was to determine the possible environmental net benefits of reducing the demand for gasoline and diesel fuel in California. For each petroleum reduction option, the ARB quantified the benefits of reducing petroleum consumption including air quality, global warming, and other impacts. The benefits were then translated into monetary terms and presented in the technical appendix entitled *Appendix A: Benefits for Reducing Demand for Gasoline and Diesel (Task 1)*.

Task 2: The second task was led by the Energy Commission to determine the future demand for refined products, particularly gasoline and diesel fuels. The results of this task are contained in a technical appendix entitled *Appendix B: Base Case Forecast of California Transportation Energy Demand (Task 2)*. In this report, the Energy Commission forecast vehicle miles traveled and demand for gasoline and diesel fuels based on projections of personal income, population and forecasted prices for petroleum and refined products through 2020 (with an extrapolation through 2030).

Task 3: The objective of this task, led by the Energy Commission, was to assess possible options to reduce petroleum dependency and determine the level of petroleum reduction and costs. The amount of gasoline and diesel fuel reduced, the consumer cost, and the change in government revenue were determined for each of the options. The results of this effort are summarized in this technical appendix, entitled *Appendix C: Petroleum Reduction Options (Task 3)*.

Task 4: The Energy Commission and the ARB jointly led Task 4, which provided an integration of the results of Tasks 1, 2, and 3. The results of Task 4 are contained in a technical appendix entitled *Appendix D: Costs and Benefits of Reduction Options (Task 4)*.

Options to Reduce California's Petroleum Dependence (Task 3)

The potential for reducing California's petroleum dependence can be assessed by reviewing a wide range of technology, fuel, and demand reduction options. This technical appendix describes the methodology used in the Task 3 analysis and presents an evaluation of each option. The options evaluated are divided into four categories.

Group 1: Fuel Efficiency Options. The staff evaluated a variety of measures to improve transportation energy efficiency. These measures include the following:

- Improved Vehicle Fuel Economy
- Fuel-Efficient Replacement Tires and Tire Inflation
- Fuel-Efficient Vehicles in Government Fleets
- Improved Vehicle Maintenance Practices
- More Efficient On-Road Diesel Medium- and Heavy-Duty Trucks
- Light-Duty Diesel Vehicles

Group 2: Fuel Substitution Options. Advanced technologies and alternative fuels can reduce petroleum dependence. Options evaluated in this category are as follows:

- Fuel Cells
- Electric Battery Technologies
- Grid-Connected Hybrid Electric Vehicles
- CNG for Light-Duty Vehicles
- Liquefied Petroleum Gas (LPG)
- Alcohol Fuels in Flexible Fuel Vehicles
- Use of Ethanol in California Reformulated Gasoline
- Liquefied Natural Gas and Advanced Natural Gas Engines for Medium- and Heavy-Duty Vehicles
- Fischer-Tropsch Diesel
- Biodiesel

Group 3: Pricing Options. Pricing measures tied either to fuel use or vehicle miles traveled can reduce consumer fuel demand. Such measures include the following:

- Gasoline Tax
- Marginal Cost Pricing for Auto Insurance
- Tax on Vehicle Miles Traveled
- Feebates
- Registration Fee Transfer
- Purchase Incentives for Efficient Vehicles

Group 4: Other Options. The staff explored other policies to reduce the demand for gasoline and diesel fuel including:

- Expanded Use of Public Transit
- Land Use Planning
- Telecommuting
- Reducing Speed Limits
- Voluntary Accelerated Vehicle Retirement
- Ridesharing

All of the options are briefly described in the following sections of this technical appendix and structured in the following manner:

Description: A short description of the option evaluated.

Background: A general discussion of the technology involved, any related legislation or other material needed to understand the issues with the particular option.

Assumptions and Methodology: A discussion of the general assumptions and methodology were used in the analysis.

Status: A discussion that describes the current state of development for that particular technology.

Results: The specific quantified results from the analysis showing the option's petroleum reduction compared to the base case.

Key Drivers and Uncertainties: Key drivers and uncertainties that could significantly change the results of the analysis.

In addition, the following attachments have been included in this technical appendix:

- Attachment A: Methodology
- Attachment B: Staff Papers on Petroleum Reduction Options
- Attachment C: Ethanol Demand and Supply Analysis

GROUP 1
FUEL EFFICIENCY OPTIONS

Option 1A
Improved Vehicle Fuel Economy

Description

This option is based on increasing light-duty gasoline vehicle efficiency by means of advanced vehicle technologies. The technologies include advanced internal combustion engines (hybrid-electric propulsion), integrated starter-generators and transmissions, as well as a myriad of other improvements that enhance fuel economy relative to more traditional vehicle equipment.

Increasing fuel economy levels provides the opportunity to meet transportation demand with less fuel. As a result, increasing vehicle efficiency, particularly in mass-production vehicles that constitute the majority of transportation energy demand, can result in significant reductions in petroleum use.

Background

Fuel economy improvements for commercially viable, production-volume vehicles have had significant attention and study. Because of the significant capital investments in vehicle manufacturing, as well as the product cycles of automobiles, most work examining changes in automotive product offerings considers scenarios for several years in the future. We used vehicle fuel economy analyses performed by the American Council for an Energy-Efficient Economy[1] (ACEEE), the National Research Council[2] (NRC), and Energy and Environmental Analysis, Inc.[3] (EEA) to develop ten cases for potential future fuel economy improvements. The staff supplemented the ACEEE mild hybrid and full hybrid vehicle costs with cost estimates prepared by the ARB staff. These works were consulted as they collectively provide a range of potential incremental technology costs and fuel economy levels. The findings of these studies are used to estimate a range of petroleum demand reductions possible for California.

One of the NRC report findings is that incremental improvements occur each year, but that significant changes, such as major fuel economy improvements, take decades to penetrate the market in significant quantities. The report also notes that automobile manufacturers have improved vehicle performance while maintaining federal Corporate Average Fuel Economy (CAFE) requirements.

The ACEEE, NRC, and EEA studies together consider several technology levels or “packages” that could be used to achieve improved vehicle fuel economy. These packages include various technologies and are not limited to a particular device or implement. Rather, these technology options are assembled into systems that would collectively deliver improved fuel economy. Each is compared to a base case average fuel economy of 20.4 miles per gallon for all new light-duty vehicles and is described below.

ACEEE Study. The purpose of the ACEEE study was to provide an assessment of “technically optimum” applications of affordable vehicle efficiency improvements to allow policy makers to make more informed decisions. However, the ACEEE study did not include plug-in hybrid vehicles. The authors defined four vehicle fuel economy improvement treatments as follows:

1. **Moderate** (29.9 mpg weighted average fuel economy). This treatment uses current trends in the automotive industry to apply improvements that increase fuel economy, including some improvements now intended primarily to enhance performance rather than fuel economy.[4] These include the following:

- mass reduction (0 percent for small cars, 10 percent for mid-sized cars, and 20 percent for minivans, pickups, and SUVs);
- aerodynamic streamlining to reduce drag 10 percent;
- more use of low rolling resistance tires (for 20 percent less rolling resistance);
- more efficient accessories;
- an advanced, high-efficiency gasoline engine (50 kilowatts per liter in place of the current 43 kilowatts per litter, without direct injection);
- integrated starter-generator with 42-volt system; and
- improved electronically controlled transmissions (continuously variable transmissions for cars and 5-speed automatics for trucks).

No size reductions are needed. However, small cars become slightly larger. Some of these options have already entered the market.

2. **Advanced** (34.4 mpg). This treatment extends the moderate treatment by using:

- more mass reduction (10 percent for small cars, 20 percent for mid-sized cars, and 33 percent for minivans, pickups, and SUVs);
- the same streamlining, low rolling resistance tires, and accessory improvements as the moderate treatment;
- an advanced, direct-injection gasoline engine (55 kilowatts per liter);
- the same integrated starter-generator with 42-volt system as the moderate case; and
- advanced electronically controlled transmissions (continuously variable transmissions for cars and 6-speed transmissions for other vehicles, all fully optimized for low emissions, low fuel consumption, and low road-load operation).

Advanced, compact and integrated engine-transmission power trains contribute to weight reductions, but SUV mass reductions also require new materials.

3. **Mild Hybrid** (39.9 mpg). This treatment assumes that mild hybrids will extend the advanced treatment by adding a hybrid-electric power train and electric power for 15 percent of peak power to achieve 15 to 18 percent further fuel economy improvements.[5] The Honda Insight mild hybrid vehicle, with an aluminum body, is identified in the report as "an Advanced Package platform." Two categories of incremental vehicle costs are used for each of six vehicle classes. One price category is directly from the ACEEE report and represents an evolutionary process of future cost reductions as the market matures. The other price category is labeled "ARB" and represents a more aggressive cost reduction pathway, especially requiring major cost reductions for motor-controller hardware and batteries by the 2016 model year.

4. **Full Hybrid** (45.0 mpg). This treatment extends the mild hybrid treatment by using electric power for 40 percent of peak power to achieve 29 to 33 percent fuel economy improvement over the advanced treatment. Two price categories are used, as discussed above for mild hybrid vehicles.

NRC Study. The NRC study developed three successively more aggressive (and costly) product development paths that include both production-intent and emerging technologies.[6] Emerging technologies are identified below with a (E). Treatments vary for various vehicle classes. Common to all three paths discussed below and for most vehicle classes within them are reduced engine friction, low friction engine lubricants, variable valve timing, more efficient engine accessories, improved rolling resistance tires, and reduced aerodynamic drag. Also, all include the effects of a 5 percent vehicle weight increase for safety (and an associated fuel economy penalty). The NRC study did not include any hybrid or diesel vehicles. The authors defined three vehicle fuel economy improvement Paths (treatments) as follows:

1. **Path 1** (23.2 mpg). Path 1 uses mostly competition-driven, production-intent technologies available at current fuel prices. Vehicle performance is held constant. Specific treatments are as follows:

    - multi-valve overhead camshafts for larger vehicles,
    - 5-speed automatic transmissions with advanced shift logic,
    - cylinder deactivation in SUVs and small pickups, and
    - 42-volt electrical systems in passenger cars (E).

2. **Path 2** (27.9 mpg). This path extends Path 1 by using more costly production-intent technologies. They also make greater use of emerging technologies. Specific treatments include:

    - multi-valve, overhead camshafts for larger vehicles,
    - variable valve lifting and timing,
    - cylinder deactivation for SUVS and pickups,
    - 5-speed or 6-speed automatic transmissions for larger vehicles,
    - continuously variable transmissions for smaller vehicles,
    - intake valve throttling (E),
    - automatic shift manual transmissions (except subcompacts and compacts) (E),
    - 42-volt systems (except subcompacts and compacts) (E), and
    - electric power steering (except subcompacts, compacts and small SUVs) (E).

3. **Path 3** (31.4 mpg). Path 3 requires the aggressive use of production-intent technologies expected to become available within the next 10 years and the extensive use of emerging technologies. Specific treatments include the following:

- multi-valve overhead camshafts in larger vehicles,
- variable valve lift and timing,
- cylinder deactivation in larger vehicles,
- engine supercharging and downsizing (excludes subcompacts and compacts),
- continuously variable transmissions in most vehicle classes,
- camless valve actuation (E),
- variable compression ratios (E),
- advanced, high torque continuously variable transmissions for some vehicle classes (E),
- 42-volt systems for all vehicle classes (E),
- integrated starter/generator for all vehicle classes (E),
- electric power steering for all vehicle classes(E), and
- vehicle weight reductions for larger sedans and larger SUVs.

EEA Study. Energy and Environmental Analysis, Inc. (EEA) was retained to assess the potential for improved vehicle fuel economy attributes. EEA also served as a contractor to the NRC study and incorporated new information from the NRC effort into work performed for the Energy Commission. In the EEA case, specific technology enhancements incorporated to various degrees in each vehicle class are listed below:

- composite aluminum and ultra-high strength steel vehicle bodies,
- electric power steering,
- variable valve timing,
- cylinder deactivation,
- advanced torque converter,
- continuously variable transmissions,
- electrically shifted manual transmissions,
- 42 volt hybrids, and
- on-demand electric four wheel drive.

Status

In the Energy Policy and Conservation Act of 1975, the U.S. Congress determined that it was in the national interest to reduce petroleum dependence by establishing CAFE standards. Congress increased new vehicle light-duty passenger car fuel economy from 18 miles per gallon in 1978 to 27.5 miles per gallon in 1985. This has remained the CAFE standard. The federal Department of Transportation set similar standards for light trucks, now at 20.7 miles per gallon.

The CAFE program has been controversial since inception. Stakeholders debate the effect of CAFE on fleet average fuel economy, the resultant mix of vehicles consumers operate, safety implications, the health of the U.S. automotive industry, and the well-being of consumers.

Overall new light duty vehicle fuel economy improved from 1978 to 1988, but has since declined due to consumers purchasing increasing quantities of vehicles, including sport utility vehicles, that are built to meet light truck rather than light car CAFE requirements. Light truck sales increased from about 19 percent in 1975 to 28 percent in 1987 and 46 percent in 2000.[7]

Automobile manufacturers have improved vehicle performance while maintaining federal CAFE requirements. For example, since about 1981, manufacturers have improved the horsepower-to-weight ratio about 50 percent and reduced the 0-to-60 miles per hour acceleration by 26 percent. Furthermore, customers have apparently been willing to pay for the cost of these improvements. In 1980, a new car cost about $15,900, while by the year 2000 a new car cost about $22,300.[8] Correspondingly, fuel economy remained relatively constant while horsepower, weight, horsepower/weight ratio, and top speed all increased.[9]

In 2001, Congress asked the National Academy of Sciences to study CAFE requirements, including potential fuel economy improvements and their impact on motor vehicle safety, employment, the automotive business sector, the consumer, and the impact of different CAFE requirements for both domestic and non-domestic vehicle sales. The results of this study were published in a report entitled *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*.

Assumptions

The Energy Commission's consultant, TIAX, developed a spreadsheet tool to estimate the cost tradeoff between incremental capital cost and fuel savings over a vehicle's life, using advanced energy efficiency technologies listed above in new light-duty vehicles.[10]

Fuel Economy Levels. Table 1A-1 shows the level of fuel economy improvement modeled for 13 vehicle classes and each technology evaluated. To accomplish this, it was necessary to associate the five vehicle classes used in the ACEEE study and the ten vehicle classes used in the NRC study with the 13 vehicle classes used in FUTURES. This was accomplished by matching vehicle classes where appropriate. For example, the ACEEE small car results were assumed to apply for the mini car, subcompact, and compact vehicle classes for purposes of determining fuel economy improvement and incremental price.[11]

Table 1A-1. On Road and EPA-Rated Fuel Economy Levels for Each Case

Vehicle Class	EEA Baseline	2008-2030 On-Road Fuel Economy (mpg)							EEA MY '20-'30
		Moderate	Advanced	Mild Hybrid	Full Hybrid	NRC Path 1	NRC Path 2	NRC Path 3	
Mini Car	38.4	54.6	60.3	70.3	79.2	42.6	46.0	53.9	53.2
Subcompact	29.1	41.4	45.7	53.3	60.0	32.3	34.9	40.8	41.0
Compact	25.6	36.4	40.2	46.8	52.7	28.4	31.1	36.5	34.8
Midsize	22.0	34.3	38.4	44.2	49.7	24.3	29.2	33.5	31.1
Full Size Car	20.2	31.5	35.4	40.6	45.7	22.7	28.1	31.9	27.4
Sports Car	22.7	35.4	39.7	45.5	51.2	25.5	31.5	35.8	28.6
Mini Van	22.1	34.2	40.8	47.9	54.1	25.4	32.6	35.1	29.3
Standard Van	15.1	23.5	28.0	32.8	37.1	17.4	22.4	24.1	19.2
Compact Pickup	19.2	26.4	31.0	35.8	40.4	22.6	28.2	30.4	25.9
Standard Pickup	14.1	19.4	22.8	26.3	29.7	16.2	21.5	22.5	20.6
Mini SUV	23.0	35.0	40.9	48.1	54.1	25.3	30.0	34.8	35.7
Compact SUV	16.8	25.5	29.9	35.1	39.5	20.2	24.6	27.3	22.9
Standard SUV	13.8	21.0	24.6	28.8	32.4	16.6	19.8	22.8	19.9
On-Road Avg. FE	20.4	29.9	34.4	39.9	45.0	23.3	28.0	31.4	27.7
EPA Rated	24.3	35.6	40.9	47.5	53.5	27.7	33.3	37.4	33.0

For the FUTURES simulations, fuel efficiency improvements relative to the base case forecast were determined by factoring up the CALCARS baseline estimates using the percent improvements determined in the NRC and ACEEE studies.[12] Because of the complexity of designing and manufacturing automobiles, it was assumed that six years would be needed before new technologies could enter the California market place. In these simulations, during the seven-year implementation period, one-seventh of new vehicles in each class were assumed to have the fuel economy listed in Table 1A-1. Deployment was assumed to begin in model year 2008 and proceed uniformly for 7 years, with 100 percent of new vehicle sales occurring by 2014. This allows for a relatively normal turnover rate of vehicle technology, as it usually takes about 7 years for new technologies to saturate new vehicle sales. This is not meant to suggest, however, that these market penetrations are going to occur. Rather, the assumptions assist in constructing a reasonable bound for what is possible in terms of petroleum reduction, fuel savings and associated economic effects.

For the EEA case, fuel economy improvements, vehicle cost increases, and changes in other attributes relative to the base case were projected directly by EEA. In this case, fuel economy for new vehicles increases more or less gradually (beginning in 2008) over a twelve-year period. The entries in Table 1A-1 for EEA are projections for the model years 2020 to 2030. The EEA results start at lower levels and then level off at the values shown in Table 1A-1. By 2020, projected fuel efficiencies would be 15 to 35 percent higher, depending on vehicle class, than the figures for 2008.

Table 1A-2 shows the incremental vehicle capital costs for each vehicle class and technology improvement case considered. These costs represent analysts' best estimates of the incremental cost of incorporating each technology in national new car sales. The estimates of incremental costs for state-only implementation may be somewhat higher (see key drivers and uncertainties below).[13]

Table 1A-2. Incremental Capital Cost Assumptions for Each Case (Nationwide Deployment)

	Increased Cost of New Vehicles (2001 $)									
Vehicle Class	Moderate	Advanced	ACEEE Mild Hybrid	ARB Mild Hybrid	ACEEE Full Hybrid	ARB Full Hybrid	NRC Path 1	NRC Path 2	NRC Path 3	EEA MY '20-'30
Mini Car	950	1,150	3,200	1,050	4,425	2,325	475	1,025	2,100	822
Subcompact	950	1,150	3,200	1,050	4,425	2,325	475	1,025	2,100	778
Compact	950	1,150	3,200	1,050	4,425	2,325	475	1,075	2,175	841
Midsize	1,050	1,325	3,600	1,250	5,200	2,625	475	1,650	3,250	992
Full Size Car	1,050	1,325	3,600	1,450	5,200	3,150	675	2,175	3,525	943
Sports Car	1,050	1,325	3,600	1,250	5,200	2,625	675	2,175	3,525	480
Mini Van	1,550	2,175	4,250	1,500	5,950	3,300	575	2,225	3,025	737
Standard Van	1,550	2,175	4,250	1,700	5,950	3,800	575	2,225	3,025	693
Compact PU	1,550	2,350	4,650	1,700	6,675	3,800	675	2,225	3,375	599
Standard PU	1,550	2,350	4,650	1,700	6,675	3,800	575	2,550	3,025	611
Mini SUV	1,425	2,150	4,100	1,400	5,600	3,025	475	1,550	2,650	793
Compact SUV	1,425	2,150	4,100	1,400	5,600	3,025	775	2,225	3,650	750
Standard SUV	1,425	2,150	4,100	1,400	5,600	3,025	775	2,075	3,300	790

Results

Gasoline demand reductions for each case are given in Table 1A-3 and are expressed in terms of millions of gallons of gasoline saved and percent saved relative to the base case forecast for total gasoline demand (not just light-duty vehicles), assuming our median gasoline prices forecast of $1.64 per gallon.[14] Potential fuel savings are bounded by NRC Path 1 on the lower end, displacing 10.8 percent of the otherwise expected gasoline demand in 2030, with the upper bound corresponding to ACEEE-Full Hybrid technology which displaces 50.3 percent of the gasoline demand in 2030.

Table 1A-3. Gasoline Reduction from Improved Vehicle Fuel Economy ($1.64 per gallon)

	2020		2030	
Case	**Annual Reduction (million gallons)**	**Reduction from Base Case (Percent)**	**Annual Reduction (million gallons)**	**Reduction from Base Case (Percent)**
ACEEE Moderate	4,055	21.7	6,281	29.1
ACEEE Advanced	5,195	27.8	8,040	37.2
ACEEE Mild Hybrid	6,274	33.5	9,709	45.0
ARB Mild Hybrid	6,274	33.5	9,709	45.0
ACEEE Full Hybrid	7,016	37.5	10,856	50.3
ARB Full Hybrid	7,016	37.5	10,856	50.3
NRC Path 1	1,511	8.1	2,339	10.8
NRC Path 2	3,427	18.3	5,302	24.6
NRC Path 3	4,461	23.8	6,903	32.0
EEA	2,908	15.5	5,031	23.3

Figure 1A-1 shows projected fuel demand for each case. The more aggressive cases lower gasoline demand nearly to 2002 levels, and a few project gasoline demand lower than 2002 consumption. However, even in the most aggressive case of the full hybrid vehicle, gasoline demand stops declining and even begins to grow by 2030 as the new technologies saturate the market and vehicle miles traveled continue to grow. Most of the cases could accomplish very significant petroleum demand reduction if implemented for California.

Direct Economic Benefits of Gasoline Demand Reductions. The increased fuel savings associated with higher fuel economy levels come with higher vehicle costs due to the associated technologies. In many cases, the cost of the new technologies is fully offset by the value of the fuel savings. However, this is not true for all cases.

Table 1A-4 shows the cumulative benefit to consumers (not including environmental benefits) from 2002 to 2020 and 2030, and their relative rank. Negative values are shown with curved brackets and represent increased costs rather than a benefit. The most cost-effective cases from a

Figure 1A-1. Fuel Consumption for Each Case from 2002 to 2050 at $1.64 per Gallon

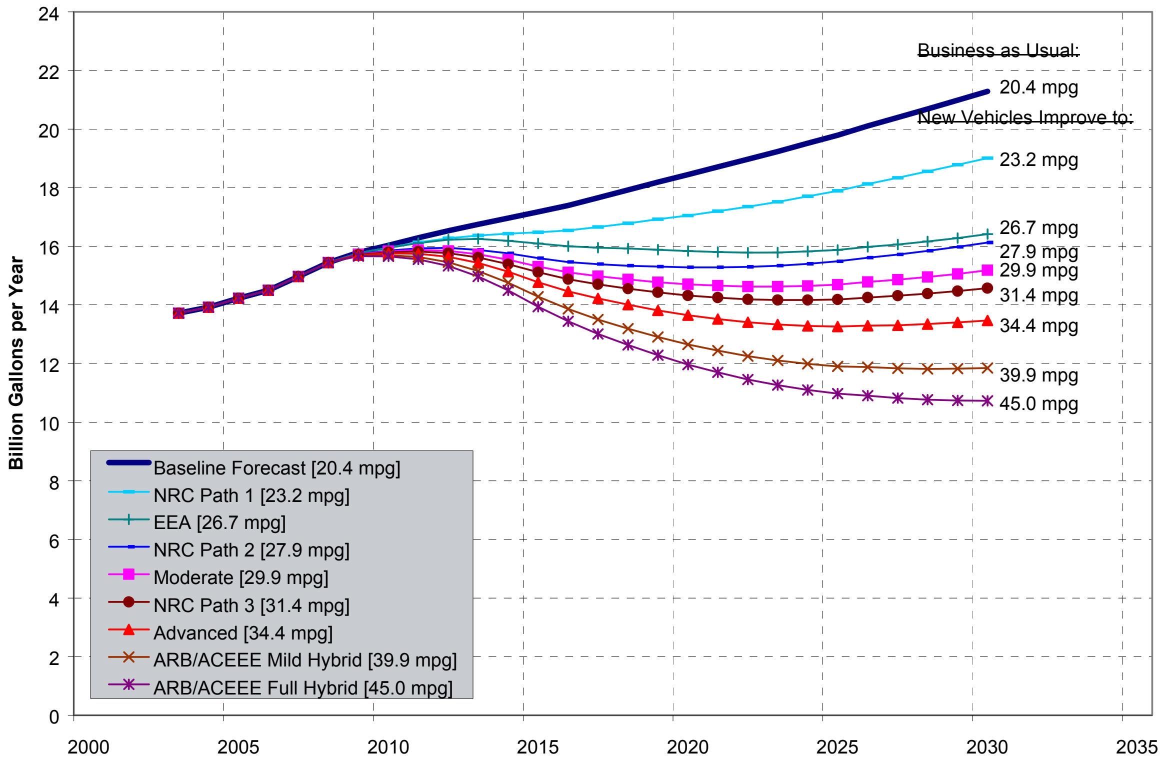

Table 1A-4. Present Value of Consumers Benefits at $1.64 per Gallon
(Million 2001$)

Case	2002-2020	Rank	2002-2030	Rank
ACEEE Moderate	10,697	2	26,644	3
ACEEE Advanced	12,859	1	32,101	2
ACEEE Mild Hybrid	1,828	7	7,885	8
ARB Mild Hybrid	7,452	4	34,588	1
ACEEE Full Hybrid	(6,386)	10	(10,182)	10
ARB Full Hybrid	(1,114)	9	14,738	5
NRC Path 1	3,117	6	7,931	7
NRC Path 2	3,336	5	9,571	6
NRC Path 3	(429)	8	1,682	9
EEA	9,879	3	24,743	4

consumer perspective are the ARB Mild Hybrid, ACEEE Advanced, ACEEE Moderate, and EEA.

Summed over 2002 to 2020, the ACEEE Advanced case provides the best net present value from a consumer perspective. This case is followed by the ACEEE Moderate case, then EEA case, ARB Mild Hybrid case and NRC Path 2 case. Seven of the 10 cases provide net consumer benefits. Summed over 2002 to 2030, the ARB Mild Hybrid case provides the best net present value to consumers, followed by the ACEEE Advanced, ACEEE Moderate, and EEA case. Nine of the 10 cases provide net consumer benefits over this longer time period.

One criticism of measures designed to improve fuel efficiency has been that consumers are more interested in higher vehicle performance than they are in fuel efficiency gains; these results show that consumers are better off with improved fuel economy even when performance effects are included.[15]

Table 1A-5 shows the impact of each option on gasoline revenue collected by the government. All values are shown in curved brackets to represent a loss to government. Government revenue losses include state and federal excise taxes but are offset partially by lower federal ethanol subsidy payments (staff subtracted 2.9 cents per gallon, assuming 5.7 percent by volume of ethanol per gallon). Sales tax effects are not included. These losses are proportional to the fuel displacements over the same time periods. The negative entries for government revenues represent the reduction in gasoline excise taxes (less gasoline sold) collected relative to the base case forecast.

Table 1A-5. Present Value of Change in Government Revenue at $1.64 per Gallon (Million 2001$)

Case	2002-2020	2002-2030
ACEEE Moderate	(2,219)	(9,795)
ACEEE Advanced	(2,852)	(12,561)
ACEEE Mild Hybrid	(3,445)	(15,170)
ARB Mild Hybrid	(3,445)	(15,170)
ACEEE Full Hybrid	(3,852)	(16,964)
ARB Full Hybrid	(3,852)	(16,964)
NRC Path 1	(829)	(3,653)
NRC Path 2	(1,881)	(8,286)
NRC Path 3	(2,449)	(10,786)
EEA	(1,388)	(6,969)

Table 1A-6 shows the net effect, taking into account the savings (or increased costs) experienced by consumers and the loss of government revenue. The numbers in Table 1A-6 are the net of higher vehicle costs, reduced expenditures on fuel, and the loss in government excise tax revenue.[16]

Table 1A-6. Present Value of Net Benefits at $1.64 per Gallon (Million 2001$)

Case	2002-2020	Rank	2002-2030	Rank
ACEEE Moderate	8,478	3	16,849	4
ACEEE Advanced	10,007	1	19,540	1
ACEEE Mild Hybrid	(1,617)	7	(7,285)	8
ARB Mild Hybrid	4,007	4	19,417	2
ACEEE Full Hybrid	(10,238)	10	(27,146)	10
ARB Full Hybrid	(4,966)	9	(2,226)	7
NRC Path 1	2,288	5	4,278	5
NRC Path 2	1,455	6	1,285	6
NRC Path 3	(2,878)	8	(9,104)	9
EEA	8,491	2	17,774	3

Key Drivers and Uncertainties

Several variables interact to impact the results for each case. Changes in these variables, such as fuel price or technology cost, can dramatically alter the relative rankings of each case.

- **Incremental Capital Costs.** Each of the cases is based upon incremental capital costs associated with nationwide implementation of the associated technologies. Although we do not have estimates of their magnitude, a California-only implementation could result in somewhat higher vehicle costs. Also, in the analysis, we held the fuel price constant. If gasoline demand were to drop to the degree shown in Figure 1A-1, oil companies would likely respond by lowering retail fuel prices. This would tend to make the more efficient technologies less cost-effective (simply because the fuel being displaced would cost consumers less).

- **Gasoline Fuel Price.** Future gasoline prices have a greater effect on the results than any other variable in this study. Consistent with the Energy Commission's projections of fuel prices for this study, the cases reported above assume a constant fuel price of $1.64 per gallon of gasoline from 2008 to 2030. Sensitivity analyses were performed using gasoline prices with a low value of $1.47 per gallon and a high value of $1.81 per gallon, representing a cost range of minus and plus one standard deviation. See Attachment A for additional discussion on this topic.

- **Technology Cost Estimates.** The technology costs in this work are based on estimates derived by the NRC, ACEEE, ARB and EEA. Each of these estimates represents careful, thoughtful analysis. However, the long-term nature of these forecasts results in a significant degree of uncertainty in the technology costs used in this examination. The economic impacts calculated in this effort are, not surprisingly, highly dependent upon the assumed cost of improved fuel economy. NRC and ACEEE incremental capital costs were adjusted to 2001 dollars and then rounded to the nearest $25.

The studies were consulted to minimize this uncertainty by examining a range of costs. This effort presents this range as an attempt to bracket potential costs and benefits. It is likely that the actual range of technology costs is narrower than those presented here, as industry innovation is difficult to predict. This is especially true for the most advanced fuel efficiency technologies like full hybrids since cost estimates for this technology are "best guesses" today. The implications of these shifts in technology cost, however, are obvious. Lower technology costs not only mean higher "net" benefits, but they also lead to broader technology use and introduction.

In order to translate technology improvements into real world fuel economy improvements, consumers will have to decide that vehicles have attained sufficiently improved performance, and that further technology improvements are worth the extra price they will require.

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[1] *Technical Options for Improving the Fuel Economy of U.S. Cars and Light Trucks by 2010-2105*, ACEEE, April 2001.

[2] *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*, Committee on the Effectiveness and Impact of Corporate Average Fuel Economy (CAFÉ) Standards, National Research Council (NRC), National Academy Press.

[3] *Analysis and Forecast of the Performance and Cost of Conventional and Electric Hybrid Vehicles*, Energy and Environmental Analysis, Inc., February 2002 (Final Report).

[4] Numerical values in brackets are computed by FUTURES. They should be compared to "business as usual" at 20.4 mpg.

[5] Near-term hybrids now being introduced by automobile manufacturers are more likely to use technologies from the moderate treatment (see text for an exception for the Honda Insight).

[6] Production-intent technologies are well known to manufacturers and could be quickly incorporated into vehicles once a decision is made to use them. Some are already available. Emerging technologies are generally beyond the research phase and are fundamentally sound, but need more development before they could be incorporated into vehicles. They should be available within 10 to 15 years.

[7] Data from Reference 1.

[8] NRC, Figure 2-8, adjusted to $2001 dollars.

[9] NRC, Figure 2-7.

[10] Data from the ACEEE, ARB and NRC studies were used for incremental vehicle cost and associated fuel savings. The corresponding per vehicle class data on projected vehicle sales, sales percentages, and vehicle miles traveled were obtained from CALCARS for base case results under future fuel prices of $1.47 per gallon, $1.64 per gallon and $1.81 per gallon. In addition to fuel use, FUTURES provides direct costs and fuel savings benefits to vehicle consumers, but does not account for consumer value of other vehicle attributes such as performance.

[11] The numbers in each class for 2002, the base year used in CALCARS, come from California Department of Motor Vehicles registration data. The baseline fuel economy values in this table are predicted by EEA for 2002.

[12] CALCARS is a behaviorally-based vehicle choice, usage, and demand model estimated specifically for California. The model predicts at the household level, using 57 types of households that vary by annual income, number of members, and number of employed members.

[13] In general, capital costs were obtained directly from the two references, adjusting to year 2001 dollars, and rounding to the nearest $25. These values were applied to the 13 vehicle classes in the same manner as the fuel economy values. One variation is that the ACEEE Mild Hybrid and ACEEE Full Hybrid cases were supplemented with lower cost data based upon ARB staff estimates for price reductions that could occur by 2015 due to market growth that reduces battery costs and technology evolution that significantly reduces electric motor and controller costs. More moderate cost reductions are assumed for the 2010 to 2015 time period. These ARB values were not rounded to the nearest $25. These cases are called "ARB Mild Hybrid" and "ARB Full Hybrid"cases. The fuel economy was the same as corresponding ACEEE cases.

[14] Total gasoline demand includes gasoline demand for light-duty vehicles and heavier vehicles, mainly medium-duty vehicles. Light-duty gasoline demand is estimated at 13.7 billion gallons by 2003 and the total gasoline demand is estimated at 14.7 billion gallons by 2003.

[15] There may well be effects not captured here; for example, vehicle weight reductions. In providing a revised set of vehicle attributes for this analysis, EEA assumed that higher fuel economy requirements induce manufacturers to reduce slightly the weight of some models to improve fuel efficiency, and weight is not included as a vehicle characteristic in CALCARS. Therefore, to the extent vehicle owners value weight as an attribute, the estimated net benefits of higher fuel economy may be overstated. As another example, manufacturer efforts to improve fuel economy may involve the use of composite materials that can potentially prolong the life of a vehicle.

[16] There are likely to be other effects on vehicle attributes that may impose costs or provide additional benefits to buyers. The effect of changes in vehicle performance levels is considered in the CALCARS simulation used to develop initial market percentages for use by FUTURES.

Option 1B
Fuel-Efficient Replacement Tires and Tire Inflation

Description

In this option staff evaluates possible reductions in fuel consumption through greater use of low-rolling resistance (LRR) replacement tires and through better monitoring of tire inflation pressures. This result would be achieved through an education program on 1) energy efficiency performance of tires and 2) the benefits of using LRR replacement tires and for keeping tires properly inflated. Additionally, to increase the result from this option, consumers could be provided tire pressure measuring devices and minimum tire efficiency standards could be adopted.

Background

Vehicle tires that are under-inflated result in increased energy consumption. According to a recent survey by the National Highway Transportation Safety Administration (NHTSA), 27 percent of passenger cars and 32 percent of light trucks are driven with one or more substantially under-inflated tires.[1] An under-inflated tire is defined as being at least 8 pounds per square inch (psi) below manufacturer's recommended pressure, or 25 percent below the commonly recommended inflation pressure of 32 psi. According to the Environmental Protection Agency, under-inflated tires can lower gasoline fuel economy (in miles per gallon) by 0.4 percent for every 1 psi drop in pressure of all four tires.[2]

According to the American Council for an Energy Efficient Economy, LRR tires are introduced as original automotive equipment to help meet Corporate Average Fleet Economy standards in new vehicles.[3] LRR tires can reduce the negative effect of friction by up to 20 percent, providing a fuel economy improvement of 3 to 4 percent without compromising vehicle safety and handling.[4]

Because tires are not currently labeled with energy related information and consumer information on this subject is lacking, consumers are unaware of the fuel consumption implications of their choices for purchasing replacement tires. Consequently, consumers purchase many after-market replacement tires that result in greater energy consumption compared to original equipment tires.

The Natural Resources Defense Council estimates that the energy savings from fuel-efficient replacement tires could approach 5.4 billion barrels of oil over the next 50 years, the equivalent of 70 percent of the total oil available from the Arctic Refuge in Alaska.[5]

Status

Senate Bill 1170 (Sher, Chapter 912, Statutes of 2001) directs the Energy Commission to evaluate ways to increase automotive fuel-efficiency in the state government's motor vehicle fleet by 10 percent. The Energy Commission and the Department of General Services will jointly study the potential fuel-economy improvements possible through state government purchase of fuel-efficient vehicles and tires. The Energy Commission will conduct a separate evaluation on the use of more energy-efficient tires.[6] Unfortunately, all of the results of this evaluation did not become available in time to be fully considered in this analysis. The estimated range of efficiency impact in this evaluation, however, is consistent with the efficiency improvement value used in the AB 2076 analysis. The agencies completed their studies on January 31, 2003, including recommendations on a state tire efficiency program.

Assumptions

In the base case demand forecast, about 39 percent of California's light-duty vehicles are pickup trucks (includes minivans and sport utility vehicles) and 61 percent are passenger cars. Applying NHTSA data on tire under-inflation, the staff calculated that about 30 percent of the state's light-duty fleet population operate with under-inflated tires. The staff assumes that a consumer education campaign on tire inflation could influence up to 30 percent of these motorists to inflate their tires properly.[7] A more accurate estimate will likely require actual market testing to determine the percentage of consumers influenced by a campaign and its related investment level. Based on NHTSA data and the relationship of rolling resistance, tire pressure, and increased fuel economy, the NRDC estimates that if all tires were properly inflated, on-road passenger vehicle fuel consumption would decrease by about 2 percent.[8]

In this analysis, based on the life of average tires and data obtained from Michelin on the rolling resistance of tires, the staff assumes that approximately 60 percent of the on-road vehicle fleet have replacement tires, and that 80 percent of those vehicles have tires that are not low-rolling resistance tires.[9] A consumer education campaign on LRR tires is assumed to influence 30 percent of the motorists who normally do not purchase LRR replacement tires.

Low-Rolling Resistance Tires

- The minimum estimated annual cost for a public outreach campaign is $10 million. A more accurate cost estimate will likely require actual market testing to determine a limiting cost-benefit ratio. See Attachment A for additional discussion on media campaigns.

- The annual cost of establishing tire rating and labeling system and tire testing is $1 million.

- The estimated cost per vehicle for low-rolling tires: $40/vehicle/3-years.[10]

- The gasoline price was from the base case forecast of $1.64 per gallon, plus or minus $0.17 per gallon (one standard deviation in the monthly average retail price over the most recent 5 calendar year period).

Proper Air Inflation for Tires

- The minimum estimated annual cost for a public outreach campaign is $10 million.

- The cost to consumer for each vehicle is $0.00 (Zero).

- The improved inflation monitoring has a significant beneficial effect on tire life but is not included in this cost-benefit analysis.

Results

The use of low rolling resistance tires, combined with proper tire inflation, can reduce annual gasoline consumption by almost 2 percent, when compared to the base case gasoline demand forecast. More detailed results are located in Attachment B.

Table 1B-1. Combined Low Rolling Resistance Tires and Tire Inflation Estimated Gasoline Reduction

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	308	352	405
Reduction From Base Case Demand (percent)	1.8	1.8	1.8

Consumers who choose to purchase LRR tires and maintain proper tire inflation can save money. This consumer benefit result is shown in Column A of Table 1B-2. Savings grow over time. This option reduces government revenue due to reduced collection of fuel excise taxes and expenditures for the public education campaign (see Column B). However, the consumer benefits exceed the losses in government revenue and produce positive net benefits (Column C). When monetary results from Task 1 are combined with Task 3, the absolute magnitude of benefits can increase or decrease.

Table 1B-2. Direct Non-Environmental Benefits from Fuel Efficient Tires and Tire Inflation (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	1,193	(430)	763
2002-2020	3,161	(1,064)	2,097
2002-2030	4,540	(1,504)	3,036
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key drivers in this analysis involve:

- The cost of low-rolling resistance replacement tires.

- The increase in fuel economy from improved tire inflation practices and LRR tires.

- Consumer response to information on proper tire inflation and tire efficiency characteristics.

- There is uncertainty in the estimated number of vehicles that are currently using less efficient replacement tires and operating with under-inflated tires. These values bound the potential energy savings that might result from a change in consumer decision-making.

- There is uncertainty in the proportion of consumers willing to purchase more efficient tires and to monitor their tire inflation level frequently. A greater fraction of consumers who adopt these practices will make any public investments to promote greater efficiency more cost effective and vice versa. However, for the assumed efficiency improvements, the cost savings per consumer will remain unchanged. There is also uncertainty in the level of higher retail prices that consumers would be willing to pay for low-rolling resistance tires.

- If the TREAD Act requires manufacturers to provide inflation pressure monitoring devices in new vehicles, additional fuel economy gains can be expected.[11] Inflation monitoring devices will likely increase the proportion of vehicles with properly inflated tires. This would change the fuel demand forecast of the base case and reduce the opportunity for savings calculated in this analysis. The change in consumer practice could eventually approach 100 percent, resulting in a 1 percent reduction in annual gasoline use. However, this additional reduction would not be achieved until the entire California vehicle population was replaced with vehicles built after implementation of the TREAD Act. A complete fleet turnover might then be achieved in the 2020 to 2030 time frame.

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[1] U.S. Department of Transportation National Highway Traffic Safety Administration, Consumer Information regulations Uniform Tire Quality Grading Standards, 60 Fed. Reg. 27472 (May 1995).

[2] United States Environmental Protection Agency website, [www.fueleconomy.gov], 2002.

[3] John DeCicco, American Council for an Energy-Efficient Economy, Facsimile, July 11, 2000.

[4] K.G. Duleep, National Highway Transportation Safety Administration Docket, August 1995.

[5] "A Responsible Energy Policy for the 21[St] Century" National Resources Defense Council, March 2001.

[6] *California State Fuel-Efficiency Tire Report, Volumes 1 and 2*, [www.energy.ca.gov/transportation/tire_efficiency/documents/index.html], January 2003.

[7] This value is estimated from other public information programs. See the discussion in the Methodology Section (Attachment A).

[8] Roland Hwang, National Resources Defense Council calculations via e-mailed spreadsheet, March 2002.

[9] Michelin, August 9, 1994.

[10] Informal staff survey and cost judgment, David Ashuckian, August 2002.

[11] National Highway Transportation Safety Administration, *TREAD Milestones*, [www.nhtsa.dot.gov/cars/rules/rulings/tread/MileStones/index.html].

Option 1C
Government Fleets

Description

This option would require all government agencies in California, including local, state, and federal fleets to select the most fuel-efficient vehicle in each vehicle class for one-third of their purchases when purchasing new vehicles, excluding law enforcement vehicles.

Background

There are currently 231,000 light-duty vehicles in government fleets in California; approximately 41,000 of those are in the State of California's fleet. The historic growth rate of the government vehicle population in California is 2 percent per year.[1]

Status

Government vehicles have historically been purchased to satisfy the needs of each agency and meet the requirements of the national Energy Policy Act (EPAct) of 1992. Currently, the EPAct requires federal and state fleet operators to replace 75 percent of all new vehicles with vehicles capable of operating on an alternative fuel. The desired outcome is a reduction in the use of petroleum fuels. However, there is no requirement that these fleets use an alternative fuel, resulting in little or no reduction in petroleum use. In addition, emergency vehicles, local government vehicles, and vehicles that have a gross vehicle weight over 8,500 pounds are exempt from EPAct requirements.

Assumptions

This analysis assumes that, beginning in 2005, one-third of new vehicle purchases each year would meet the criterion of most fuel efficient in vehicle class for that model year. Government fleet vehicles are generally replaced at a rate of 10 percent per year.[2] This turnover rate implies a vehicle service life of 10 years.

An informal survey of two relatively large government fleets, the California Department of General Services Fleet Administration Office (DGS) and Sacramento County, indicates that the annual purchase of law enforcement vehicles can be as high as two-thirds of their total light-duty vehicle acquisitions. This leaves a potential balance of one-third that may have the flexibility to use best-in-class fuel economy as a purchasing criterion.

The average light-duty vehicle fuel economy for the best-in-class vehicle classes purchased by government fleets is assumed to be 28 mpg (combined city and highway, Corporate Average Fuel Economy value). This value is calculated from the best-in-class vehicles purchased by the DGS in 2001 and uses CAFE city and highway fuel economy values measured by the U.S. EPA.

The average fuel economy for the population of light-duty vehicles purchased by DGS in 2001 and considered in this analysis is 21.6 mpg (combined city and highway value). The potential reduction in gasoline use due to the adoption of a best-in-class fuel economy criterion is based on the difference in fuel economy between an average light-duty vehicle and the best-in-class vehicle (21.6 versus 28 mpg).

Results

More fuel-efficient government fleet purchases can reduce gasoline use by up to 0.07 percent of the base case forecast. This result is shown in Table 1C-1. Although the annual reduction per vehicle is about 132 gallons (12,500 miles per year), nearly a 23 percent reduction in annual fuel use per vehicle, the percent reduction compared to the base case is small because the population of government vehicles is small compared to the entire light-duty fleet population. More detailed results are located in Attachment B.

Table 1C-1. Gasoline Reduction from Government Fleets

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	7	13.7	16.7
Reduction From Base Case Demand (percent)	0.04	0.07	0.07

The purchase of best-in-class fuel economy vehicles by government fleets can produce savings in operating costs. This result is displayed in Column A of Table 1C-2. The savings exceed the losses in government revenue that occur from reduced collection of fuel excise taxes (Column B) and produce positive net benefits (Column C).

Table 1C-2. Direct Non-Environmental Benefits from Government Fleets (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	29	(6)	23
2002-2020	130	(26)	104
2002-2030	210	(43)	167
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis involve:

- The determination of annual new vehicle purchases by California's local, state, and federal governments.
- The current and future fuel economy performance of government fleets.
- The fraction of new purchases that could be selected from a set of best-in-class fuel economy vehicles.
- The possible limitation imposed by the EPAct requirements to purchase alternative fueled vehicles instead of fuel efficient gasoline vehicles.
- The number of flexible fuel or dual fuel vehicles in government fleets that currently use an alternative fuel.

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[1] California Department of Motor Vehicle Data, 2001.

[2] Discussion with Department of General Services, Office of Fleet Procurement staff, November 2001.

Option 1D
Vehicle Maintenance Practices

Description

This option involves a state campaign to educate motorists on the benefits of improved maintenance practices to reduce the future demand for gasoline consumption.

Background

In the near-term, improving the efficiency performance of California's vehicle population can be achieved by focusing on vehicle related measures that do not require time for technology advancement and can be initiated solely through individual or state action. In general, these actions might include periodic engine tune-ups, engine lubrication, changes of air and oil filters, and proper tire inflation levels.

The U.S. DOE estimates that maintenance practices can improve individual vehicle fuel economy by 1 to 10 percent for air filters and 1 to 2 percent for oil and oil filter changes.[1]

Status

It is likely that engines in California vehicles that are not operating well are being identified through the State's Smog Check Program. A large fraction of vehicles that could improve fuel economy performance through a tune-up are already accounted for as part of the base case demand forecast. The potential impact of maintaining proper tire inflation is being evaluated under a separate analysis related to tire replacement and maintenance. As a result, the estimated fuel reduction from improved vehicle maintenance practices will focus on periodic changing of engine lubrication and air and oil filters.

The survey data from the Car Care Council indicate that in 2000, 10 percent of the vehicle population has an air filter requiring replacement, and 20 percent of the vehicle population has exceeded their oil and filter change interval.[2] These values were used to calculate the upper bound fraction of the fleet population (opportunity fleet) that might contribute to improved fuel economy.

Assumptions

Individual vehicle fuel economy improvement is 2 percent for air filter changes and 2 percent for oil and oil filter changes. The staff assumed that the Smog Check Program finds air filter changes and oil and oil filter changes that have efficiency improvements beyond 2 percent.

The assumed cost for air filter change is $15 (biennial) and for oil and oil filter change is $25 (annual).

The air filter would be changed every other year ($15/filter). Oil and filter changes would occur twice a year (about $5.50/filter, $1.35/quart of oil, 5 quarts/oil change).[3] No specific cost assumption was made for labor expenses if automotive service providers performed these practices.

The staff assumed an education campaign would influence 30 percent of the opportunity fleet to perform more periodic oil and oil filter and air filter changes. A more accurate estimate will likely require actual market testing to determine the percentage of consumers influenced by a campaign and its related investment level.

The staff assumed a consumer education campaign to inform motorists on the benefits of improved maintenance practices would have an annual cost of $10 million. A more accurate cost estimate will likely require actual market testing to determine a limiting cost-benefit ratio. See Attachment A for additional discussion on media campaigns.

The opportunity fleet population is a subset of the projected light-duty vehicle fleet from the Base Case CALCARS model for the years 2002 through 2020. Values beyond 2020 were extrapolated from the projected trends.

Results

As shown in Table 1D-1, the amount of gasoline reduction due to the maintenance practices considered is about 0.23 percent of the base case gasoline demand forecast. More detailed results are located in Attachment B.

Table 1D-1. Combined Gasoline Reduction from Air Filter and Oil and Oil Filter Changes

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	40.2	45.8	52.5
Reduction From Base Case Demand (percent)	0.23	0.23	0.23

The economic analysis shows that consumers can save money by performing regular maintenance on air filters and oil and oil filters (Column A of Table 1D-2). However, the consumer savings from reduced fuel consumption do not exceed the combined losses in fuel excise taxes and expenditures for a public education campaign (columns B and C, respectively). Thus, the net benefits are negative.

If benefits beyond reduced fuel consumption are considered when consumers perform recommended maintenance practices, the consumer benefits will be greater than shown in Table 1D-2 and net benefits are likely to be positive. Manufacturers recommend that these practices be performed at a specific frequency to insure that vehicles perform as designed and normal engine life is attained. Thus, these operational benefits, including fuel economy benefits, can be considered to be equal to or greater than the associated maintenance costs.

Table 1D-2. Direct Non-Environmental Benefits from Improved Vehicle Maintenance (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	Direct Non-Environmental Consumer Benefits (million $)	Change in Government Revenue (million $)	Direct Non-Environmental Net Benefits (million $)
2002-2010	48.9	(102.3)	(53.4)
2002-2020	125.5	(229.4)	(103.9)
2002-2030	177.2	(314.2)	(137.0)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis are as follows:

- The reduction in petroleum fuel demand is linearly dependent on the number of vehicles that take advantage of frequent changes in air or oil filters and engine lubrication and the number of operators influenced by the media campaign. The resulting reduction would double if the fraction of the opportunity fleet responding to the media campaign increased to 100 percent from 50 percent. Conversely, the value would decrease by half if 25 percent of the opportunity fleet adopted the practice.

- The consumer benefit result, a savings or a loss, depends on the magnitude of the fuel economy improvement, related annual expenditure, and the cost of gasoline.

- There is uncertainty regarding the fraction of consumers who do not perform maintenance with the frequency recommended by vehicle manufacturers. While statistics were used to estimate the fraction of consumers who have not performed maintenance on time, these statistics do not indicate when or if the consumer eventually decides to perform maintenance as a normal practice. This added knowledge would help to establish the baseline condition from which we could measure the effect of a change in consumer habit. The analysis did not attempt to determine the proportion of consumers (with an ill-maintained vehicle) who may just delay performing maintenance practices by a fraction of the recommended frequency. Thus, the analysis assumed that the tardy consumers would have skipped the full time increment for recommended maintenance and compared the value of this lost maintenance benefit to the maintenance expenditure. The benefit values shown may then be greater than the benefits that would actually occur.

- Normally, there are other benefits that motorists seek and receive when they perform these relatively routine maintenance practices. For many motorists, those benefits are greater than the savings from reduced fuel consumption. The results projected for cost-benefit underestimate the overall magnitude of consumer benefits for the maintenance options evaluated. The estimated fuel savings exceed the value of expenditures for new filters and oil changes.

[1][www.fueleconomy.gov/feg/maintain.shtml], November 2001.

[2] [www.carcarecouncil.org], National Car Care Month Inspections, 1996-2000, November 2001.

[3] Informal survey of retail prices for filters and oil at auto parts store, Dan Fong, California Energy Commission, November 2001.

Option 1E
More Efficient On-Road Diesel Medium- and Heavy-Duty Trucks

Description

For this option staff evaluates the potential of more efficient on-road diesel trucks in medium- and heavy-duty vehicle classifications to reduce the demand for diesel fuel.[1] Two scenarios of improved fuel economy are used to project upper and lower bound impacts on future diesel fuel demand in California.

Background

Assessments to determine potential vehicle and truck fuel economy improvement have been conducted since the early 1970's. The staff relied on several of those studies to determine the potential for reducing petroleum use from heavy-duty vehicles in this option.

The National Energy Modeling System (NEMS) projects fuel economy improvements based on truck efficiency gains of 0.4 percent per year from a 1982 baseline of 5.2 miles per gallon (mpg).[2] (NEMS is a model used by the U.S. DOE's Energy Information Administration). If this improvement rate is maintained, then the fuel economy of heavy-duty trucks (Classes 7 and 8) will have improved to 6.76, 7.04, and 7.33 mpg by 2010, 2020, and 2030, respectively. At the same improvement rate, the improvement potential for medium-duty vehicles (Classes 3-6) could result in fuel economy levels of 13, 13.5, and 14.1 mpg by 2010, 2020, and 2030, respectively.

In another technology assessment, DeCicco cites KG Duleep's (1997) estimate for new heavy-duty truck fuel economy improvements of 1.2 percent per year. This rate of improvement would result in fuel economy values for heavy-duty trucks of 7.3, 8.3, and 9.3 mpg by 2010, 2020, and 2030, respectively. The corresponding numbers for medium-duty vehicles are 14.1, 15.9, and 17.9 mpg by 2010,2020, and 2030, respectively.

The ACEEE's *Transportation Energy Issues through 2030* report assesses long-term potential for heavy-duty truck fuel economy improvement as 65 percent by 2030 over 1990 levels.[3] This is equivalent to a 1.65 percent annual improvement rate over the 40 year period.

The staff took a simple average of these three previous estimates and the observed annual fuel economy improvement rate of 1.25 percent in the last two decades to establish a lower bound fuel economy improvement rate of 1.125 percent for this analysis. The fuel economy values generated from the 1.125 percent annual fuel economy improvement rate are used in the Scenario 1 analysis later. The fuel economy estimates based on this approach are lower than the Department of Energy's 21st Century Program goals, discussed next.

Status

The U.S. DOE's 21st Century Truck Program is a government-industry initiative to double the 2000 fuel economy of a prototype Class 8 truck on a ton-mile/gallon basis by 2010.[4] The Truck Program will also triple the fuel economy of a prototype representative Class 2b-6 vehicle, as well as transit buses, on a miles per gallon basis by 2010, while meeting prevailing emission standards.[5]

Anticipated improvements in diesel vehicle technologies are the bases for the projected efficiency gains. Technology development and commercialization prospects were determined feasible from a comprehensive assessment of potential technologies in the 21st Century Truck Program Roadmap. According to the Roadmap, fuel economy improvements are possible from a suite of technologies that include combustion improvements, vehicle weight reduction, the use of hybrid and auxiliary power technologies, aerodynamic improvements, and rolling and inertia resistance improvements.

Assumptions

Two scenarios of improved fuel economy are used to project upper and lower bound impacts on future diesel fuel demand in California.

Scenario 1 (Nominal Fuel Economy Improvement). The first scenario is a lower bound scenario. In this scenario, the staff assumes fuel economy targets that are less aggressive than the 21st Century Program targets, which rely on breakthrough technologies. This scenario is based on previous studies that suggest modest efficiency gain potential for medium- and heavy-duty vehicles. The penetration rates for Scenario 1 are varied, according to the schedule in Table 1E-1, as a fraction of new vehicle sales to correspond to product development, commercialization schedules, and implemented policy initiatives. Moderate fuel economy improvements (38 percent for medium duty and 30 percent for heavy duty by 2030 over year 2000 levels) are also derived. The composite fuel economy improvement is based on the average of the observed historical fuel economy improvement rate for heavy-duty vehicles and model projections from studies performed by the ACEEE and the EIA.

Table 1E-1. Penetration Rates and Periods for Advanced Heavy-Duty Diesel as a Fraction of New Vehicle Sales (percent)

Period	Class 3-6	Class 7 & 8
2002-2007	Negligible	Negligible
2008-2010	14.3	14.3
2011-2020	57	57
2021-2030	100	100

Based on the penetration rate assumptions, the number of new vehicles using more efficient diesel technologies, and entering service, in the relevant milestone years are estimated. The number of vehicles with improved fuel use are about 1,000 new vehicles per year for 2002 to

2010, 6,300 vehicles per year for 2011 to 2020 and 11,000 vehicles annually from 2021 through 2030.

Scenario 2 (Aggressive Fuel Economy Improvement). The second scenario is an upper bound scenario. Under this scenario, the staff assumes implementation of a national fuel economy standard for the heavy-duty vehicle fleet based on the U.S. DOE's 21st Century Truck Program targets. The penetration rates for Scenario 2 are the same as Scenario 1. Aggressive fuel economy improvements (100 percent for classes 3-6 and 100 percent for classes 7-8 by 2030 over year 2000 levels) are also derived. These meet the DOE's 21st Century Truck Program goals, which rely on breakthrough technologies.

The following assumptions and methodology are common to the two scenarios considered:

- The assumed fuel economy targets are achieved.

- The 21st Century Truck Program Goals are established as federal fuel economy standards for 2010 and beyond (Scenario 2).

- All new vehicles sold comply with the assumed federal fuel economy standards.

- All new vehicles sold comply with the prevailing emission standards.

- Variable penetration rates in all vehicle classes with higher rates in some time periods.[6]

- Certain costs for achieving the fuel economy targets and the estimated petroleum displacements include the added capital costs for hybrid propulsion systems in certain vehicle classes, new electrical systems, and new materials. The costs are distributed across the vehicle classes.

Results

More efficient heavy-duty diesel vehicles can reduce future diesel demand by up to 10 percent by 2030. Tables 1E-2 and 1E-3 show the results for class 3-6 vehicles, and Tables 1E-4 and 1E-5 show the results for class 7-8 vehicles. The results are shown for a range of capital costs and associated efficiency improvement. More detailed results and discussions are located in Attachments A and B.

Table 1E-2. Diesel Reduction from More Efficient On-Road Diesel Trucks (Class 3-6)

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	2 – 4	23 – 40	46 – 81
Reduction From Base Case Demand (percent)	0.1	0.5 – 1.0	0.9 – 1.7

Table 1E-3. Direct Non-Environmental Benefits from More Efficient On-Road Diesel Trucks—Class 3-6 (present values, 2002 base year, 2001$, $1.65/gallon diesel)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	1 – 6	(2) – (1)	0 – 4
2002-2020	48 – 164	(53) – (30)	18 – 111
2002-2030	151 – 454	(143) – (80)	71 - 311
*Negative values are enclosed in parentheses.			

Table 1E-4. Diesel Reduction from More Efficient On-Road Diesel Trucks (Class 7-8)

	Year		
	2010	**2020**	**2030**
Strategy Results (millions of gallons)	11 – 23	118 – 251	239 – 509
Reduction From Base Case Demand (percent)	0.3 – 0.6	2.8 – 6.0	4.9 – 10.5

Table 1E-5. Direct Non-Environmental Benefits from More Efficient On-Road Diesel Trucks—Class 7-8 (present values, 2002 base year, 2001$, $1.65/gallon diesel)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	22 – 49	(14) – (7)	15 – 36
2002-2020	551 – 1,229	(336) – (158)	393 – 893
2002-2030	1,496 – 3,311	(897) – (422)	1,074 – 2,414
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis include:

- Assuming that a fuel economy standard will be established to spur industry to achieve the assumed fuel economies.
- Vehicle class distribution does not change.
- Material and manufacturing costs associated with achieving higher fuel economy.
- Vehicle Miles Traveled (affects demand reduction and incremental operating costs).
- Rapid fleet turnover in the years 2015-2030 as vehicle fleet ages and replacement justified by lower operating cost from more fuel-efficient vehicles.

[1] For this analysis, on-road medium- and heavy-duty vehicles are defined as vehicles weighing greater than 14,000 pounds gross vehicle weight.

[2] DeCicco, John M. *Transportation Energy Issues through 2030*, American Council for an Energy-Efficient Economy, December 1997.

[3] Ibid.

[4] *Technology Roadmap for the 21st Century Truck Program*, U.S. Department of Energy, December 2000.

[5] Applying the 21st Century Program targets to the year 2000 fuel economies on a mile per gallon basis will produce 13 miles per gallon for class 7-8 trucks and 38.1 miles per gallon for class 3-6 trucks. However, because of the uncertainty in implementing the breakthrough technologies to triple the fuel economy for class 3-6 vehicles, the analytical team lowered the fuel economy improvement target for class 3-6 vehicles to match the 2x multiplier for class 7-8 vehicles. Therefore, this analysis uses a fuel economy target of 25.4 mpg for class 3-6 vehicles.

[6] As used in this analysis, vehicle penetration rate means a percentage of new vehicles entering the existing fleet population. For this scenario, 100 percent of new vehicles sold meet the fuel economy standards. It is estimated that new vehicle sales are fewer than 10 percent of the existing population in any given year. The penetration rate is varied during the analysis period.

The penetration rate is lower (1 to 2 percent) in some years due to smaller production runs and slower adoption of the technology in certain vehicle classes, as well as market maturation or saturation. The rate is higher (5-7 percent) in some years, due to the rapid turnover of the vehicle population, which is assumed to occur in the years 2015-2030 from aging and the availability of more efficient vehicles. The penetration rate is moderate (3-4 percent) in other years as the market matures and demand stabilizes. A composite vehicle class distribution is used in estimating the vehicle penetrations.

Option 1F
Light-Duty Diesel Vehicles

Description

In this option the staff examines the decreased use of gasoline when light-duty diesel vehicles (LDV) are substituted for gasoline vehicles.

Background

Because of its combustion characteristics, diesel fuel can be used in a compression ignition engine (commonly called a diesel engine). In practice, this type of engine has a potential energy efficiency that is greater than a gasoline fueled engine.

The information adapted from an assessment performed by the U.S. DOE comparing projected vehicle cost and fuel economy levels for different gasoline and diesel light-duty vehicle sizes is presented in Table 1F-1.[1] The DOE believes that its various research and development programs for diesel engine technology can lead to the incremental vehicle prices and fuel economy levels shown in this table.[2] The incremental values include the cost difference between a diesel engine and a gasoline engine. The diesel engine technology used in the comparison was compression ignition, direct injection (CIDI).

Table 1F-1. Direct Injection Diesel Vehicles and Comparable Gasoline Vehicles

Vehicle Size	Fuel	1)Introduction Year 2) Maturity	Vehicle Price, $[a]	Diesel Incremental Price, $	Volumetric Fuel Economy Multiplier Compared to Gasoline[b]
Small Car	Diesel	1) 2003	17,300	1,100	1.40
		2) 2008	17,300	1,100	1.40
	Gasoline	1996	16,200	--	1.00
Large Car[c]	Diesel	1) 2005	27,200	1,800	1.35
		2) 2010	26,700	1,300	1.35
	Gasoline	1996	25,400	--	1.00
Sport Utility Vehicle	Diesel	1) 2004	25,100	1,800	1.45
		2) 2009	24,900	1,600	1.45
	Gasoline	1996	23,300	--	1.00
Minivan	Diesel	1) 2004	26,000	1,900	1.45
		2) 2009	25,800	1,700	1.45
	Gasoline	1996	24,100	--	1.00
Pickup Trucks, Large Vans	Diesel	1) 2002	18,100	1,700	1.35
		2) 2007	17,600	1,200	1.35
	Gasoline	1996	16,400	--	1.00

[a]The original 1996 costs were adjusted for inflation and brought to 2001$. An Energy Commission factor, the GDP Implicit Price Deflator (1998 = 100), was applied to the 1996 vehicle costs. For this case, the factor was 1.0946 (106.23/97.05).
[b]The fuel economy improvement of the diesel vehicle includes the impact of satisfying the Tier II federal emission standards.
[c]The Large vehicle size includes intermediate sized vehicles.

used in the comparison was a 1996 model year vehicle in the size classes shown, the prices that are displayed in the table have been adjusted to 2001$.

The DOE advanced technology, light-duty diesel vehicles indicated in Table 1F-1 are also targeted to meet the Tier II federal emission standards. The federal standards define emission performance levels in groupings of different emission levels of criteria pollutants over time. These groupings allow a manufacturer to place various vehicle models in different emission bins. Some of the emission bins correspond to the expected performance levels of California's Low Emission Vehicle II (LEV II) categories. The federal standards differ by including emission bins that are not as stringent as California's LEV II categories in the near term and by requiring a fleet average threshold for nitrogen oxide (NO_x) instead of non-methane organic gases (NMOG). Over time, however, the federal system essentially merges with the LEV II categories. For this analysis, the Tier II technology diesel vehicle will be assumed to require additional emission control equipment to meet California LEV II standards beginning in model year 2007.

Status

Debate exists as to whether emission control technology can be developed to enable light-duty diesel vehicles to meet California's 2007 exhaust emission standards. Industry representatives have stated that they will be able to develop satisfactory technology when used with expected low sulfur diesel (15 ppm sulfur), while public health advocates emphasize that no engines have been certified at this time and that future technologies and emission reductions are still uncertain. In the simplest terms, if manufacturers are unable to meet requirements, vehicles will not be sold. If current emission standards are found inadequate to protect health, they will be strengthened, and diesel technologies may or may not meet them.

Because of a variety of market constraints, light-duty diesel vehicles in California have historically experienced low sales when compared to gasoline vehicles. With the exception of vans and heavier pickups (8,501 – 10,000 lbs. gross vehicle weight), the market share of 2000 model year diesel vehicles in lighter classes was much less than 10 percent. Growth in diesel sales has not occurred in vehicle classes less than 8,500 pounds gross vehicle weight because they have been unable to comply with California emission standards. California's light-duty vehicle population, excluding commercial fleets, is currently near 20 million, and only about 300,000 vehicles are registered as diesel fueled.

Even though the current market for light-duty diesels in California seems very limited, policies in Europe and vehicle performance improvements have led to a much larger market share for diesels than in California.[3] The 2000 European LDV market share (annual sales) for diesel varies from about 10 percent in the United Kingdom to between 50 and 60 percent in France, Spain, and Austria.[4] Although the European experience may not be comparable to California due to different economic conditions and uncertainty regarding compliance with emission standards, California consumers could potentially choose an increasing proportion of diesel models over comparable gasoline models.

Market penetration analysis conducted by DOE for light-duty diesel vehicles, using the vehicle classes with the attributes shown in Table 1F-1, shows an annual new vehicle market share peaking at about 20 percent by 2012.[5] If the incremental vehicle price used in DOE's analysis assumed additional cost for emission control equipment, it is likely that their consumer choice model would project a lower market share.

Assumptions

Technologies are now being developed and evaluated as potential emission control measures for advanced diesel engines. For the purpose of this analysis, the estimates of the additional cost due to these technologies have been extrapolated from projected costs made by the U.S. Environmental Protection Agency (EPA) for heavy-duty vehicles.[6] The relative size of key emission control components, (the NO_x adsorber, catalyzed particulate filter, and the like) were determined to be scaled to engine displacement. Thus, the relative cost of these components can also be related to engine size.

The U.S. EPA's estimates of diesel vehicle incremental price due to emission control additions were for light-heavy, medium-heavy, and heavy-heavy diesel trucks. These truck classes were assumed to use engines with displacements of 6, 8, and 13.3 liters, respectively. The diesel engine sizes that are likely to be found in a light-duty vehicle range from 2 to 6 liters. The incremental emission control costs (consumer prices) for the light-duty vehicles were extrapolated from the larger engine estimates.

From the data gathered, the range of estimated fuel economy improvement for a light-duty diesel, expressed as a fuel economy multiplier, is 1.35 to 1.56. Staff assumed that the average light-duty diesel vehicle will likely have a fuel economy improvement range bounded by these values. Since actual on-road fuel economy can be less than certification or experimental test results, the value that is used in the comparison analysis is 1.45, weighted toward the values estimated by DOE.

Staff assumed that highly efficient NO_x and particulate matter (PM) after-treatment will be available and used on light duty diesel vehicles beginning in 2007, allowing a growth in sales to occur. Low sulfur diesel fuel will also be available in mid-2006, as currently required by the U.S. EPA.

Based upon the results of a 1998-1999 survey of approximately 7,500 retail service stations in California, the existing retail infrastructure for dispensing diesel is assumed adequate for the projected growth in diesel vehicle population during the initial years for the scenario evaluated.[7] The survey found that about 24 percent of the sites dispensed diesel fuel. For additional infrastructure beyond this level, the cost of expanding retail fuel stations to dispense diesel is assumed to be absorbed by private industry as a normal investment option, controlled by the economic opportunity of supplying diesel fuel to meet demand. The diesel fuel price used in the analysis includes a retail margin that would normally pay for infrastructure expenses.

Beginning in 2008, the average diesel vehicle with the near-term incremental price range begins to penetrate the fleet population. The annual new vehicle sales rate was assumed to be less than one percent of new light-duty vehicles in 2008 but ramping up to about 10 percent by 2020. From 2008 to 2012, the incremental vehicle price linearly declines to the long-term range and is constant thereafter. The diesel vehicle sales rates used in this scenario are not a prediction of specific market penetration.

The estimate for petroleum fuels reduction is based on the assumption that diesel vehicles meeting 2007 California emission standards would begin to be marketed in 2008. This assumption is made for comparison purposes with other fuel displacement options.

Although some data indicate that a diesel vehicle depreciates at a lower rate compared to a gasoline vehicle, the data do not extend to a wide group of models sold in the light-duty vehicle market. Thus, both diesel and gasoline vehicles are assumed to depreciate at the same rate.

Diesel and gasoline fuel prices that were projected for the base case energy demand forecast were used with a standard deviation of $.17 per gallon, based upon historical monthly price variations.

Results

Tables 1F-2 and 1F-3 display the results for gasoline reduction from light-duty diesel vehicles. The light-duty diesel option provides near-term net savings over the largest range of input assumptions considered in this analysis. The results are expressed for a range of capital costs. More detailed results and discussions are located in Attachments A and B.

Table 1F-2. Gasoline Reduction from Light-Duty Diesel Vehicles

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	31	1,111	2,327
Reduction From Base Case Demand (percent)	0.2	5.7	10.4

Table 1F-3. Direct Non-Environmental Benefits from Light-Duty Diesel Vehicles (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(6) – (4)	(1)	(7) – (5)
2002-2020	141 – 231	(104)	37 – 127
2002-2030	895 – 1,165	(349)	546 - 816
*Negative values are enclosed in parentheses.			

Key Uncertainties

The key uncertainties in this analysis involve the following:

- There is uncertainty regarding California consumer response to light duty diesel vehicles under 8,500 lbs. gross vehicle weight. Logically, if other vehicle characteristics and performance levels were equal, the higher vehicle cost for a diesel would have to be defrayed by its fuel savings to persuade a large fraction of consumers to choose a diesel over a gasoline vehicle. Future gasoline vehicles may also improve their fuel economy, partially offsetting a diesel vehicle's operating cost advantage and reducing its attractiveness.

- The CAFE regulations may be revised to compel vehicle manufacturers to produce higher fuel economy for standard and compact pickup trucks. To take advantage of their higher fuel economy, manufacturers may offer additional vehicle models with diesel engines.

- For light duty vehicles with a gross vehicle weight of less than 8,500 pounds, most of which are passenger-carrying vehicles, emission regulations for HC, CO, and NO_x have been set based on the lowest achievable emission rate for gasoline vehicles. For diesel engine light duty vehicles to achieve such emissions standards, highly efficient exhaust after-treatment for both NO_x and PM is required.[8]

- A significant increase in diesel product demand may require changes to California refineries which are generally designed to maximize their gasoline production or greater volumes of diesel fuel will need to be imported to California. Diesel production is directly limited by the capacity of desulfurization units such as hydrotreaters, hydro-desulfurization units and fluid catalytic crackers.

- Other supply options that could support a larger population of light-duty diesel vehicles include greater use of synthetic fuels such as Fischer-Tropsch diesel for in-state blending and greater imports of refined diesel meeting CARB fuel specification (EPA diesel blended with Fischer-Tropsch diesel for example). These options may be less expensive compared to the cost of increasing the state's supply of diesel fuel derived from petroleum.

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[1] U.S. Department of Energy, Program Analysis Methodology, Office of Transportation Technologies, *Quality Metrics Final Report 2001*, February 23, 2000.

[2] Personal communication between Dan Fong (CEC) and Philip Patterson, U.S. DOE, Office of Transportation Technologies, June 21, 2002.

[3] Such policies include, for example, high taxation rates on fuels, favorable fuel taxation on diesel fuel versus gasoline, and different exhaust emission standards.

[4] Ward's Auto World, Super Diesels, The Market, figure on page 39, September 2001.

[5] U.S. Department of energy, Program Analysis Methodology, Office of Transportation Technologies, Quality Metrics Final Report 2001, February, 23, 2000.

[6] U.S. EPA, *Regulatory Impact Analysis: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*, December 2000, Air and Radiation, EPA420-R-00-026, December 2000.

[7] The Energy Commission used proprietary contractor survey data on about 75 percent of all California retail service stations in 1998-99 and found that about 24 percent of these sites dispensed diesel fuel. These sites were concentrated in cities and urban counties. Thus, the existing accessibility of diesel fuel is not assumed to limit the market growth for diesel vehicles.

[8] PM filters have demonstrated the efficiency needed to comply with the California PM standard for light duty diesels, and these filters are being used on some new diesel passenger cars sold in Europe. The greater challenge for diesel vehicles is the development of NOx after-treatment which is durable and of high enough efficiency to comply with the California NOx standard. Development efforts are focused on heavy-duty engines, which will require NOx after-treatment beginning in 2007. Similar technology can be used on light-duty diesel vehicles. For vehicles with gross vehicle weights in excess of 8,501 pounds, which include many work trucks, emissions standards are more closely tied to the standards for heavy-duty truck engines. This has resulted in emissions standards for heavier pickups and delivery vehicles that can be more readily met by using diesel engines, as evidenced by the substantial number of diesel vehicles being sold in this weight class.

GROUP 2
FUEL SUBSTITUTION OPTIONS

Option 2A
Fuel Cells

Description

In this option the staff examines the potential for the future of fuel cell vehicles in California's light-duty vehicle market.

Background

Fuel cell vehicles (FCVs) hold the promise of high efficiency, zero or near-zero tail pipe emissions, and little or no evaporative emissions depending on the fuel used. FCVs have the potential for significantly better fuel economy than conventional internal combustion engine (ICE) vehicles. When operating on direct hydrogen, fuel cell vehicles produce no tail pipe emissions, only water and heat.

Like batteries, fuel cells provide electricity through an electrochemical reaction. However, fuel cells do not require electric recharging. Fuel cell vehicles and battery electric vehicles are sometimes called "electric drive vehicles" and use an electric motor rather than an ICE.

All fuel cells operate on hydrogen, which can be stored on-board the vehicle (direct) or produced on-board the vehicle from a hydrocarbon fuel with a reformer (indirect). Leading candidate fuels under consideration for onboard reforming include gasoline and methanol.

While ethanol could be used as a hydrogen source for FCVs, the staff is unaware of any automobile manufacturers pursuing an ethanol FCV option. Furthermore, prices for ethanol are expected to be higher on a cost per mile basis than other fuels considered here. If ethanol were to be utilized in FCVs it could potentially be used either in a neat feedstock (E100) or blended with gasoline (i.e., E10, E20, etc.) with petroleum savings corresponding to the blend level and efficiency gains (expected to be comparable to gasoline reformers).

Concerns continue over which fuel will be used as a source of hydrogen and who will pay for FCV infrastructure development. If an appropriate fueling infrastructure is not deployed in a timely manner and with convenient access, market development for FCVs may be severely constrained. In the case of direct hydrogen fuel cell vehicles, the cost of hydrogen station development can be several times higher than existing gasoline stations. In addition, hydrogen is often seen as a dangerous fuel to store and handle, and appropriate fire and safety codes need to be developed. Over the long term, however, hydrogen provides superior environmental and potential energy benefits.

If gasoline is to be used in FCVs, either the gasoline will need to be modified (i.e., refined to ultra-low sulfur levels), or gasoline reformers must improve to handle today's gasoline designed for internal combustion engines.

Status

A few dozen light-duty FCVs are now being demonstrated around the world, notably in California under the auspices of the California Fuel Cell Partnership. Numerous automobile makers are devoting substantial resources toward the development of FCVs, with the hope that over the long term the capital cost of various fuel cell technologies will become cost competitive with the gasoline ICE vehicle (as well as other competing technologies). However, this technology is pre-commercial and the likelihood of achieving substantial market penetration is uncertain. The timing, cost and durability of fuel cell technologies are all challenges that are being addressed by stakeholders.

Over the last few years, the U.S. DOE has been increasing the amount of money being spent on fuel cell vehicle research and development (R&D).[1] Federal FCV R&D focuses on lowering fuel cell stack and reformer component costs, improving fuel processor performance targets, integrating system components, and reducing costs for onboard hydrogen storage.

In January 2002, the U.S. DOE announced the replacement of the Partnership for a New Generation of Vehicles (PNGV) with the Freedom CAR (Cooperative Automotive Research) initiative, underscoring the administration's commitment to developing FCVs. The Freedom CAR program is a public-private partnership between the U.S. DOE and Ford, General Motors and DaimlerChrysler, to promote the development of hydrogen as a primary fuel for cars and trucks.

The program will focus on the research needed to develop technologies such as fuel cells and hydrogen from domestic, renewable sources. Freedom CAR also will focus on technologies to enable mass production of affordable hydrogen-powered fuel cell vehicles and the hydrogen-supply infrastructure to support them.[2]

While reducing the fuel cell stack cost and improving durability[3] are probably the biggest challenges, several other technical design issues still must be resolved before fuel cell vehicles can become competitive with current vehicle technologies. These technical issues include fuel cell stack performance, balance of plant improvements (necessary supporting components), cold temperature operation, hydrogen storage technology, reformer development, and others.[4]

Fuel cell vehicles are at an early stage in their development, with major hurdles to overcome. Nevertheless, they show great potential and both government and private stakeholders are devoting large resources to overcome these hurdles. This process will take time. With current development progress, only a relatively small number of noncommercial FCVs will be operating by 2010.

For light-duty FCVs to achieve significant sales levels by 2012, major technical and economic breakthroughs for fuel cells need to occur no later than 2008. These breakthroughs would include improving fuel cell stack performance and reliability, improving reformer technology, significantly reducing costs for these systems, and improving hydrogen storage systems for direct hydrogen fuel cell vehicles. For example, to be competitive with gasoline ICE technology, the cost of fuel cells per kilowatt (kW) will need to drop by an order of magnitude or more from the current amount to about $45/kW (which matches the U.S. Department of Energy's goal).

In the near-term, FCVs will be costly for manufacturers to produce and sell and for owners to operate. Costs are assumed to be high compared to conventional gasoline vehicles, but falling as technology improves at a rapid pace. For example, Arthur D. Little estimates the incremental cost for FCVs during the 2010-2020 time period to be approximately $9,000-11,000 per vehicle.[5] Compared to current conventional gasoline ICE vehicles, intermediate-term market direct hydrogen FCVs that meet development goals could have 1.8 to 3.0 times higher equivalent fuel economy. Methanol steam reforming (SR) hybrid fuel cell vehicles could have 1.2 to 1.7 times higher fuel economy. Gasoline or ethanol hybrid auto-thermal reforming (ATR) fuel cell vehicles could have 1.1 to 1.6 times higher fuel economy.

Assumptions

Compared to current conventional gasoline ICE vehicles, mature market direct hydrogen FCVs that meet development goals could have 2.0 to 3.5 times higher equivalent fuel economy. Methanol SR hybrid fuel cell vehicles could have 1.2 to 1.9 times higher fuel economy. Gasoline or ethanol hybrid auto-thermal reforming (ATR) fuel cell vehicles could have 1.2 to 1.7 times higher fuel economy. Rather than using the highest estimated efficiency improvement values, the following analyses employs nominal equivalent fuel economy factors of 2.5, 1.7, and 1.5, for direct hydrogen, methanol steam reforming, and gasoline reforming, respectively.

Most of the Group 2 (Fuel Substitution) options assume that vehicle deployment will begin in 2008. However, because of the very early status of fuel cell vehicle development, it does not appear likely that this schedule could be met with fuel cell vehicles. The staff assumed, therefore, that vehicle deployment begins in 2012 for fuel cell vehicles.

The staff assumed FCV cost and performance targets of the U.S. DOE R&D programs are met. Vehicle owners will probably still have to pay more to purchase a FCV than a comparable gasoline ICE, even if R&D targets are met. However, expected fuel savings and possible higher value features of FCVs (e.g., quieter operation and increased power availability) may justify a higher vehicle purchase price.

Fuel cell vehicles could also be used as distributed resources to provide electric power to the grid. With funding from the CARB and Los Angeles Department of Water and Power, analysts at the University of Delaware evaluated the cost effectiveness of using fuel cell vehicles in this manner.[6]

The staff did not include, however, any potential revenues from the "vehicle-to-grid" use of fuel cell vehicles. The amount of revenue that could be derived from this potential application is not known, especially considering that there are several forms of potential distributed generation. Some of these may be more economically viable than fuel cell vehicles, but they were not considered in the University of Delaware study. See Option 2C (Grid-Connected Hybrids) for a more complete discussion of this topic.

Results

Tables 2A-1 and 2A-2 display the results for direct hydrogen FCVs. FCV technology using hydrogen-on-board is a long-term option with the potential to provide net savings. Tables 2A-3 and 2A-4 display the results for methanol FCVs. Tables 2A-5 and 2A-6 display the results for gasoline FCVs. Results are for the average fuel price of $1.64 per gallon and a range of hydrogen, methanol, and capital costs. More detailed results and discussions are located in Attachment B.

Table 2A-1. Gasoline Reduction from Direct Hydrogen FCVs*

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	N/A	514	1,961
Reduction From Base Case Demand (percent)	N/A	2.6	8.8
*N/A = This option was not analyzed for 2010.			

Table 2A-2. Direct Non-Environmental Benefits from Direct Hydrogen FCVs (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	N/A	N/A	N/A
2002-2020	(470) – (14)	(246)	(716) – (260)
2002-2030	(2,509) – 108	(1,604)	(4,113) – (1,496)
*Negative values are enclosed in parentheses. N/A = This option was not analyzed for 2010.			

Table 2A-3. Gasoline Reduction from Methanol FCVs*

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	N/A	514	1,961
Reduction From Base Case Demand (percent)	N/A	2.6	8.8
*N/A = This option was not analyzed for 2010.			

Table 2A-4. Direct Non-Environmental Benefits from Methanol FCVs (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	N/A	N/A	N/A
2002-2020	(525) – 2	(91)	(616) – (89)
2002-2030	(2,757) – 268	(591)	(3,349) – (323)
*Negative values are enclosed in parentheses. N/A = This option was not analyzed for 2010.			

Table 2A-5. Gasoline Reduction from Gasoline FCVs*

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	N/A	171	654
Reduction From Base Case Demand (percent)	N/A	0.9	2.9
*N/A = This option was not analyzed for 2010.			

Table 2A-6. Direct Non-Environmental Benefits from Gasoline FCVs (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	N/A	N/A	N/A
2002-2020	(524) – (82)	(82)	(606) – (164)
2002-2030	(2,690) – (155)	(535)	(3,225) – (690)
*Negative values are enclosed in parentheses. N/A = This option was not analyzed for 2010.			

Key Drivers and Uncertainties

Highlighted below are many of the major uncertainties with FCVs, and the key drivers that will ultimately determine the market success of this emerging technology.

- Costs of fuel cell system (success in meeting capital cost R&D targets) and available incentives.
- The willingness of energy industry or government to invest and initially share the cost of fueling infrastructure development, particularly important for hydrogen.
- Costs of fuel for FCVs, especially hydrogen.
- System efficiency of fuel cell vehicles (success in meeting efficiency R&D targets).
- Choice of fuel or fuels for FCVs. Several candidates are under consideration and this issue should be resolved as fuel cell stack technology advances. There is a general consensus that hydrogen is the preferred fuel in the long term, pending resolution of supply and storage issues.

[1] U.S. Department of Energy, FY 2002 Congressional Budget Request, Energy Efficiency and Renewable Energy, Energy Conservation. DOE spent $36.6 million on fuel cell vehicle research and development (R&D) in fiscal year (FY) 2000, $41.3 million in FY 2001, and requested $41.9 million for FY 2002. Correspondingly, they requested $8.7 million for electric drive vehicle (battery) R&D in FY 2000, $9.0 million in FY 2001, and $3.5 million for FY 2002.

[2] Schremp, Gordon, "Personal Communication," California Energy Commission, 2001.

[3] Improved fuel cell stack durability is defined as extending the useful life of a stack that declines over time through voltage degradation or catastrophic failure, leading to unacceptable performance.

[4] Arthur D. Little, Projected Automotive Fuel Cell Use in California, October 2001.

[5] Arthur D. Little, *Guidance for Transportation Technologies: Fuel Choice for Fuel Cell Vehicles*, December 2001 (p. 81). BKI, *Bringing Fuel Cell Vehicles to Market: Scenarios and Challenges with Fuel Alternatives*, October 2001.

[6] Kempton, Willett; Tomic and Jasna, University of Delaware; Letendre, Steven, Green Mountain College; Brooks, Alec, AC Propulsion, Inc.; and Lipman, Timothy, University of California, Berkley and Davis (2001).

Option 2B
Electric Battery Technologies

Description

In a scenario to exceed the market penetration level defined by the California Air Resources Board's Zero Emission Vehicle (ZEV) mandate, this option evaluates the cost-benefit potential of a battery-powered electric drive vehicle compared to an average base case gasoline vehicle.

Background

In 1990, the California Air Resources Board adopted low-emission vehicle standards that included a requirement that automobile manufacturers offer a minimum percentage of zero-emission vehicles for sale. Although the actual minimum percentage requirement has been reduced over the past 12 years, manufacturers must still produce and offer for sale, a limited number of zero-emission vehicles beginning in model year 2003. The commercialization status of zero-emission vehicle technology, though, limits automaker options to battery powered electric vehicles.

The development of more cost-effective battery electric drive technologies can potentially improve the competitiveness of battery-electric vehicles, fuel cell vehicles, and gasoline- electric hybrid vehicles. With additional R&D, technology advancements could increase the range and utility of these vehicles, resulting in an increased number of vehicles that could be introduced in California beyond the minimum number required by the ZEV regulation.

These technology improvements may only have a marginal impact on gasoline consumption, however, because battery electric vehicles are already included in the base case forecast at levels required by California's Low-Emission Vehicle Standards.

To respond to the requirement to offer zero-emission vehicles for sale, manufacturers have developed multiple vehicle concepts to find successful combinations of vehicle utility and cost. Whereas some models are capable of providing high speed, highway performance, new models are emerging called neighborhood electric vehicles (NEVs) and urban electric vehicles (city EVs).

NEVs are defined as low speed vehicles by the National Highway Traffic Safety Administration. These vehicles typically have a top speed of about 25 miles per hour (mph). NEVs are subject to Federal Motor Vehicle Safety Standard No. 500.

Urban electric vehicles are regular passenger cars with top speeds of about 60 mph and a range of about 50 miles. They are the same as traditional full-size passenger vehicles but in a smaller package.

Neighborhood electric vehicles are excluded from this option. Vehicles used for this purpose are operated for few miles and the potential to displace gasoline is relatively small.

Status

In efforts by automobile manufacturers to meet the CARB's ZEV program requirements, a limited number of electric drive vehicles have been offered for lease or sale. The battery electric vehicles sold today have an incremental battery cost premium of $30,000 relative to similar gasoline powered internal combustion engine vehicles. City electric vehicles available today have an incremental cost of $20,000. However, the range of these vehicle classes and the durability of their batteries have not approached the performance of similar gasoline internal combustion vehicles.

In their 1995 report, the Advanced Battery Panel estimated that to reach their projected cost targets, investments in R&D and a battery plant capable of producing batteries in volumes needed to lower unit cost would be between $180 million and $400 million over 9 years.[1] Current R&D aimed at reducing battery costs is low and declining compared to recent historical levels.[2] Federal electric vehicle R&D during that time focused on attempts to reduce battery costs. Presently, the scope of the panel's R&D funding is being reduced to concentrate instead on fuel cell vehicles.

Assumptions

The staff assumed that the ZEV mandate is met, and the base case demand level incorporates the effect of the ZEV mandate in reducing gasoline demand. To increase market penetration, lower cost batteries would be needed and there needs to be additional vehicle purchase incentives to offset the additional capital cost.

This analysis assumes that further research and development will eventually reduce the cost of batteries into the range projected by the CARB's Battery Technology Advisory Panel. This independent panel stated that nickel-metal hydride batteries show the greatest potential for reaching technical maturity and cost targets. The panel projected the mature technology cost to range from $225 to $250 per kilowatt-hour (kWh) in large production quantities of 100,000 battery packs per year.[3] This leads to an incremental price of $8,000 to $10,000 per vehicle, including an additional cost of $600 to $1,200 per vehicle for electric and thermal management systems and $1,000 for recharging infrastructure.

Recent information presented to CARB staff by one battery manufacturer estimated that Lithium-Metal-Polymer battery costs could reach $200 per kWh in high production levels.[4] This level would result in an incremental cost of approximately $7,600. Furthermore, the U.S. Advanced Battery Consortium has a goal of $150 per kWh and 300 watts per kilogram with a 10-year life using lithium-based batteries.[5] The major U.S. automobile manufacturers and U.S. DOE have jointly spent nearly $300 million since 1991 to develop such advanced batteries.

For city vehicles, the staff assumed that the cost of batteries for city EV would be approximately one-third the cost of full size battery modules with an equivalent fuel economy of 45 miles per gallon compared to the average vehicle fuel economy.[6]

One strategy for improving the cost-effectiveness of electric drive vehicles, including electric battery vehicles, is to use them for ancillary services while connected to the electric grid. See Option 2C (Grid-Connected Hybrid Electric Vehicles) for a discussion on this additional potential source of revenue. The effect of this additional revenue, if realized, would improve the cost-effectiveness of electric drive vehicles.

Battery-electric vehicle target costs and performance levels have been difficult to achieve, although some gains have occurred over the past 10 years. The capital cost, range, and operating cost of a full-function battery-electric vehicle are considerably less attractive than a gasoline powered internal combustion engine vehicle. Nevertheless, there are potentially significant environmental benefits and strong advocates for their use. If a mature market develops (beyond the mandated level of market penetration), it will occur because R&D is expanded and materials costs are reduced. This process will take time. If the cost and performance targets used in the mature market condition are met, a small number of full-function EVs could be operating in California by 2010, growing thereafter.

For consistency with other Group 2 (Fuel Substitution) options, the staff assumed that battery-electric vehicle deployment begins in 2008. For battery-electric vehicles to achieve these deployment levels, major technical and economic breakthroughs need to occur prior to 2008. These would include reducing the cost of the batteries and extending battery life.

By assuming that R&D cost and performance targets discussed above are met and adding a cost of $1,000 per vehicle for home recharging equipment and installation, the staff estimated a battery EV's lifecycle cost to vehicle owners and government. Battery replacement cost is assumed to be zero (assumes batteries last the 15 year life of the vehicle). No additional consumer cost benefits or disbenefits are included (i.e., convenience of home refueling, availability of public refueling/recharging, or loss of operating range) as these are difficult to quantify.

The staff assumed a range of 6.2 to 13.5 cents per kWh for the cost of recharging the battery. This is the range of residential retail prices estimated by the Energy Commission for Pacific Gas and Electric, Southern California Edison, San Diego Gas and Electric, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District territories out through 2012.[7] The lower number includes a 40 percent discount for off-peak charging. A 7 percent local electricity use tax is included.

The staff also evaluated the potential cost-benefits of city EVs compared to full size EVs. In this analysis, the staff assumed battery costs ranging from $2,333 to $3,400, with a 50-mile range, compared to a conventional vehicle that has a 21.2 mile per gallon fuel economy. The staff used the Society of Automotive Engineers utility factors to determine the annual number of vehicle miles traveled that a limited range vehicle would displace.

Results

Based upon an assumed vehicle penetration rate and market share, full function EVs could reduce gasoline demand as shown in Table 2B-1. This scenario, however, does not include a specific implementation strategy to reach this level of market share.

Table 2B-1. Gasoline Reduction from Electric Battery Technologies

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	31	1,111	2,327
Reduction From Base Case Demand (percent)	0.2	5.7	10.4

The results for the cost-benefit comparison between the full function EV and an average gasoline vehicle are shown in Table 2A-2. The values shown are negative. This result implies that the EV option would produce a net consumer benefit that is a monetary loss. The total net benefit is a greater loss due to the reduced collection of fuel excise taxes.

Table 2B-2. Direct Non-Environmental Benefits from Electric Battery Technologies (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(46) – (27)	(9)	(55) – (36)
2002-2020	(1,973) – (897)	(713)	(2,686) – (1,610)
2002-2030	(5,019) – (1,782)	(2,402)	(7,422) – (4,185)
*Negative values are enclosed in parentheses.			

Because the net consumer benefit shows that consumers would have to absorb higher expenses when owning and operating an EV compared to an average gasoline car, these expenses would have to be offset by other benefits or another mechanism for the EV to achieve significant market share. Without additional benefits to improve the net consumer benefit result, it is not likely that a large number of consumers would voluntarily choose an EV over the base case vehicle. Little or no incremental amount of gasoline would be displaced, as well.

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- There is uncertainty that additional research funding can reduce the cost of manufacturing advanced batteries for electric vehicles to the level assumed in this analysis.

- There is uncertainty in consumer interest in purchasing a battery electric vehicle that would still have less utility compared to a gasoline powered vehicle.

- There is uncertainty on the availability of incentives to influence consumers to acquire an electric vehicle.

- There is uncertainty in manufacturer interest in producing additional battery electric vehicles for sale.

- There is significant uncertainty in the battery replacement cost. This analysis assumes batteries will last the full 15-year life of the vehicle.

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[1] *Performance and Availability of Batteries for Electric Vehicles: a Report of the Battery Technical Advisory Panel*. 1995. F.R. Kalhammer, A. Kozawa, C.B. Moyer, B.B. Owens.

[2] The U.S. Department of Energy spent $8.7 million for electric drive vehicle R&D in FY 2000, $9.0 million in FY 2001 and requested only $3.5 million for FY 2002.

[3] *Advanced Batteries for Electric Vehicles: An Assessment of Performance, Cost, and Availability*, 2000. M. Anderman, F.R. Kalhammer, D. MacArther.

[4] Presentation by Avestor to Tom Cackette, February 2002.

[5] U.S. Advanced Battery Consortium Program Overview, March 2001.

[6] Conversation with Chuck Shulock, March 13, 2002 on City EV batteries in a mature market. CARB staff estimated cost to be 1/3 compared to full size EVs or about $3,400.

[7] *2002—2012 Electricity Outlook Report*, P700-01-004F, February 2002, Table III-2-4, adjusted to 2002 dollars.

Option 2C
Grid-Connected Hybrid Electric Vehicles

Description

In this option staff examines the use of grid-connected hybrid-electric vehicles (HEVs) to replace gasoline fueled light-duty vehicles.

Background

Grid-connected hybrid-electric vehicles (HEVs) have plug-in capabilities, a larger electric motor and larger batteries than non-grid-connected hybrid-electric vehicles. This feature allows them to achieve a portion of their travel on batteries alone. Given that approximately 63 percent of daily trips are less than 60 miles in length, grid-connected gasoline-electric hybrid vehicles with appropriately sized battery packs can replace at least one-half of all gasoline powered vehicle trips.[1] Grid-connected HEVs use the same batteries as electric battery vehicles (see Option 2B—Electric Battery Technologies), but have a smaller battery pack and correspondingly lower incremental vehicle cost.

Regulations on ZEVs adopted by the CARB may encourage automobile manufacturers to re-examine the potential for grid-connected HEVs. If grid-connected hybrid vehicles become available, they could provide an additional reduction in petroleum use compared to conventional gasoline or hybrid vehicles. However, developers still need to address battery and component costs and battery life, especially in this application with frequent shallow charging and discharging cycles.

Status

The U. S. DOE is funding research and development of hybrid electric vehicles (not just grid-connected), focusing upon improved battery packs, system component optimization, reduced ancillary loads, advanced power electronics, hybrid/electric propulsion systems, Department of Defense needs, and advanced materials and architectures.[2]

Grid-connected HEVs are undergoing research at the Electric Power Research Institute (EPRI).[3] The EPRI is focusing upon how electric grid operation can be enhanced using distributed technologies, including electric-drive vehicles such as grid-connected HEVs. The EPRI is also working with automobile manufacturers and the Department of Defense to examine the potential for grid-connected HEVs, among others.

Grid-connected HEVs are also an element in a Vehicle-to-Grid (V-2-G) power study conducted by the University of Delaware.[4] This study finds grid-connected hybrids to have significant market potential. Several aspects need further work, however, including better estimates of incremental vehicle cost, durability of batteries when used in this mode, and user behavior.[5]

A form of ancillary services called “regulation services” shows particularly strong potential, for being served by grid-connected electric-drive vehicles, because in this mode batteries would be equally charged and discharged, conserving battery energy. Ancillary services have historically been about 5 percent of the California ISO’s energy costs, costing about $1.3 billion in the first 10 months of 2001.[6] However, other issues await evaluation, including the market potential for other nontraditional sources of ancillary services.

The largest cost component for grid-connected hybrid electric vehicles is associated with the battery. This is tied directly to the incremental vehicle capital cost, and the degree to which they can displace gasoline vehicle operation. The CARB Advanced Battery Panel expects the per vehicle cost of batteries to be $13,000 to $20,000 in production quantities of 100,000 per year, reducing to about $7,000 per vehicle with additional research and development and even greater annual production.[7] See Option 2B (Electric Battery Technologies) for more discussion of battery development research and funding. For the purposes of the analysis reported below, the staff used the EPRI battery cost of $270 per kilowatt-hour.

Assumptions

This estimate of petroleum reduction assumes that these vehicles would be included as a subset of the required sales for Advanced Technology Partial Zero Emission Vehicles (AT PZEVs). The staff also assumes that these vehicles would be able to achieve 51.7 miles per gallon of gasoline during on-road engine operation. Current regulations require approximately 309,000 advanced technology PZEVs to be operating in California by 2010.

The staff analyzed the cost for a grid-connected HEV with a 60-mile all-electric range (HEV-60) and a 20-mile all-electric range (HEV-20). The staff evaluated the lifecycle cost of grid-connected HEVs in terms of vehicle owner costs and government costs, assuming that vehicle-related R&D cost and performance targets are met. The staff assumed that 74 percent of the vehicle miles of travel could be in a battery-only mode for the HEV-60 and 39 percent for the HEV-20. The staff further assumed that the fuel economy of these vehicles is 51.7 miles per gallon while operating on the gasoline engine during longer trips not served by electric-only operation.

The staff also assumed a range of 6.2 to 13.5 cents per kWh for the cost of recharging the vehicle battery pack. This is the range of residential retail prices estimated for the PG&E, SCE, SDG&E, LADWP and SMUD service territories by the California Energy Commission, with the lower value discounted by 40 percent to reflect off-peak charging,[8] as discussed in Option 2B (Electric Battery Technologies). Fuel excise taxes are assumed to be zero for the electric portion of the vehicle’s motive force. The staff included a local 7 percent user tax which tends to offset the fuel excise tax.

Using the retail price equivalent comparison developed by the EPRI for an advanced technology grid-connected hybrid electric vehicle that has a 60 mile all electric range, the cost of grid connected HEV-60 in a mature market was estimated to range between $7,000 and $9,400 per vehicle.[9] An advanced technology HEV-20 would cost between $3,450 and $5,100. This is how much more vehicle owners will probably have to pay for a grid-connected HEV compared to a conventional gasoline vehicle, even if R&D targets are met. Because the staff assumed continuation of existing fuel excise taxes, government would lose revenue because of fewer gallons of fuel sold, due to the assumed displacement of gasoline consumption by the grid-connected HEVs.

For consistency with other Group 2 (Fuel Substitution) options, staff assumed that grid-connected hybrid electric vehicle deployment begins in 2008. To achieve these deployment levels, however, major technical and economic breakthroughs need to occur by about 2006. These would include reducing the cost of the batteries and extending battery life.

Results

As discussed above, if grid-connected hybrids reach a mature level of market competitiveness, gasoline reductions could be achieved. Tables 2C-1 and 2C-2 display the results for HEV-60s. Tables 2C-3 and 2C-4 display the results for HEV-20s. The gasoline reductions shown occur due to an assumed penetration in new vehicle sales. Results are for the average fuel price of $1.64 per gallon and a range of electricity and capital costs. More detailed results and discussions are located in Attachments A and B.

Table 2C-1. Gasoline Reduction from Grid-Connected HEV-60

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	27	993	2,079
Reduction From Base Case Demand (percent)	0.2	5.1	9.3

Table 2C-2. Direct Non-Environmental Benefits from Grid-Connected HEV-60 (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(42) – (23)	(8)	(50) – (31)
2002-2020	(1,747) – (654)	(653)	(2,400) – (1,306)
2002-2030	(4,355) – (1,061)	(2,199)	(6,554) – (3,260)
*Negative values are enclosed in parentheses.			

Table 2C-3. Gasoline Reduction from Grid-Connected HEV-20

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	22	787	1,649
Reduction From Base Case Demand (percent)	0.1	4.0	7.4

Table 2C-4. Direct Non-Environmental Benefits from Grid-Connected HEV-20 (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(9) – 5	(7)	(16) – (2)
2002-2020	121 – 907	(549)	(428) – 358
2002-2030	1,239 – 3,619	(1,851)	(612) – 1,769
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis are as follows:

- There is uncertainty in the likelihood that additional research funding can reduce the cost of manufacturing advanced batteries for grid-connected hybrid electric vehicles.

- There is also uncertainty in consumer interest in purchasing a grid-connected hybrid electric vehicle that would still have a higher cost compared to hybrid-electric vehicle or conventional gasoline powered vehicle. The vehicle penetration level to meet the deployment schedule used in the analysis uses a sales rate significantly higher than market survey results from EPRI's consumer market survey.[10]

- There is also uncertainty in manufacturer interest in producing grid-connected hybrid electric vehicles.

- Finally, there is uncertainty whether grid-connected HEVs could achieve additional revenue in a V-2-G application and the resulting impact on cost effectiveness over the life of the vehicle. If the V-2-G market does develop, the grid-connected hybrid electric vehicle market may develop in a more accelerated pace with lower lifecycle costs.

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[1] Society of Automotive Engineers, *Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles*, SAE J1711 (March 1999).

[2] DOE's Hybrid Systems R&D funding was $41.8 million in Fiscal Year (FY) 2000, $49.8 million in FY 2001 and a requested $48.2 million in FY 2002.

[3] *Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options*, EPRI, Palo Alto, CA: 2001 1000349.

[4] *Vehicle-to-Grid Power: Battery, Hybrid and Fuel Cell Vehicles as Resources for Distributed Electric Power in California*, University of Delaware, June 2001.

[5] Preproposal, *Personal Electric Drive Vehicles for Vehicle-to-Grid Power: Development of Missing Parameters and User Interface*, University of Delaware, February 8, 2002.

[6] *Vehicle to Grid—A Control Area Operator's Perspective*, David Hawkins, California Independent System Operator, December 3, 2001.

[7] *Performance and Availability of Batteries for Electric Vehicles: A Report of the Battery Technical Advisory Panel*, December 11, 1995, prepared for the California Air Resources Board.

[8] *2002—2012 Electricity Outlook Report*, P700-01-004F, February 2002, Table III-2-4, adjusted to 2002 dollars.

[9] *Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options*, EPRI, Palo Alto, CA: 2001 1000349.

[10] Ibid.

Option 2D
Compressed Natural Gas for Light-Duty Vehicles

Description

In this option the staff evaluates the cost-benefit potential of Compressed Natural Gas (CNG) light-duty vehicles in comparison to average gasoline vehicles.

Background

The National Energy Policy Act of 1990 requires certain energy providers and government fleets to purchase alternative fuel vehicles (AFV). When buying new vehicles, these fleets must currently buy 75 percent of them from alternative fuel vehicle offerings. CNG vehicles would satisfy the AFV requirement.

Status

CNG vehicles are commercially available in limited quantities and vehicle models. While over 400 models of gasoline vehicles are offered for sale in model year 2003, 8 models are CNG vehicles. Approximately 2,000 light-duty CNG vehicles are sold annually to fleet operators and private consumers in California.

A number of market barriers continue to limit the penetration of CNG vehicles in California's population of light-duty vehicles. A CNG vehicle typically has reduced driving range compared to gasoline vehicles. The relatively sparse availability of CNG refueling infrastructure accessible to the public, compared to petroleum fuels, further discourages private vehicle ownership. Relatively low sales result in higher unit costs for CNG vehicles compared to gasoline vehicles. Fuel tanks capable of high pressure gas storage add significantly to incremental vehicle cost for CNG. These factors also reduce the number of CNG vehicle models offered by manufacturers.

Assumptions

The staff assumed that a home refueling device is produced and manufacturers increase production of CNG vehicle models, compared to our base case. Consistent with other options, CNG light-duty vehicles displace gasoline light-duty vehicles that average 21.2 miles per gallon.

Light-duty CNG vehicles appear to be market-ready at this time. The staff believes CNG vehicles will penetrate the gasoline vehicle market if fuel and other operational savings offset their more costly vehicle purchase prices. To date, this has not been the case and sales have been limited.

The staff assumed that light-duty CNG vehicles incremental costs are reduced from today's $4,500 to $7,500 per vehicle to a lower range of $2,500 to $5,000 per vehicle. The incremental cost includes on board storage tanks that are estimated to cost $1,000 to $1,500. Because of the limited range associated with CNG vehicles, the staff assumed the need for a home refueling unit, at an additional $1,000 per vehicle.

Results

Based upon the new vehicle penetration rate assumed for the Fuel Substitution options, the amount of gasoline reduction produced by this option is shown in Table 2D-1. More detailed results and discussions are located in Attachments A and B.

Table 2D-1. Gasoline Reduction from CNG for Light-Duty Vehicles

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	31	1,111	2,327
Reduction From Base Case Demand (percent)	0.2	5.7	10.4

Because the projected net consumer benefit is negative (Table 2D-2), consumers choosing a CNG vehicle may have to absorb a monetary loss compared to a gasoline vehicle. This result implies that an implementation strategy that offsets the monetary loss would have to be developed if the estimated gasoline reduction is to be achieved. The strategy would have to provide additional positive consumer benefits, sufficient in magnitude to make the net benefit positive.

Table 2D-2. Direct Non-Environmental Benefits from CNG for Light-Duty Vehicles (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(39) – (20)	(6)	(45) – (26)
2002-2020	(2,241) – (1,119)	(457)	(2,698) – (1,576)
2002-2030	(6,736) – (3,364)	(1,539)	(8,275) – (4,903)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

Below are the key uncertainties in this analysis:

- There is uncertainty in the number of vehicles that consumers would purchase given that CNG vehicles have a reduced range compared to conventional gasoline powered vehicles.
- There is uncertainty in the development and production of a home-refueling device that would meet consumer needs.
- There is uncertainty in the cost of large quantities of CNG stations and uncertainty in manufacturer interest in producing additional numbers of CNG vehicles.

Option 2E
Liquefied Petroleum Gas (LPG)

Description

In this option the staff examines the effect of liquefied petroleum gas (LPG) fuel displacing gasoline in light-duty vehicles.

Background

Propane is the major ingredient of LPG, which is a colorless, odorless, tasteless, and non-toxic hydrocarbon. It has a narrow flammability limit compared to gasoline, but garages and repair facilities need proper ventilation.[1] It is pressurized for use in vehicles and stored in special fuel tanks as a liquid that vaporizes to a gas before being burned in an engine. According to the Western Propane Gas Association, there are 1,200 LPG refueling facilities in California as of 2001, and half of these are capable of refueling vehicles. Because of propane's many uses (i.e., space heating, barbecues, forklifts and recreational vehicles), refueling modest numbers of LPG vehicles can be self-sustaining with little or no government support.[2]

In California, approximately one-half of the LPG supply is a byproduct of crude oil refining and the remainder is a byproduct of removing natural gas liquids at the wellhead of gas produced in California. Even though half of California's supply derives from crude oil, the staff included LPG in this analysis because it is capable of displacing gasoline and is a byproduct of refining crude oil, not the main product. LPG is comprised primarily of propane and butane, with small amounts of other natural gas and petroleum byproducts.

Status

LPG is one of the most widely used transportation fuels used today, except for gasoline and diesel. In 2000, about 268,000 LPG vehicles were operating in the United States, including 33,000 in California.[3] The staff estimates that this amount is over 60 percent of all operating alternative fuel vehicles that use non-petroleum fuels (excluding fuel flexible vehicles operating on gasoline). California's fleet represents about 12.3 percent of the nation's LPG vehicles. About 60 percent of the LPG vehicles are pickup trucks, taxis, buses, airport shuttles, and forklifts. In 1999, about 0.4 percent of the LPG used nationwide was for transportation, while California used 3.2 percent of its LPG for transportation.[4] Nationwide, in 1999, 78 percent of the LPG use was in industrial applications.

The propane supply industry indicates that four types of Original Equipment Manufacturer (OEM) vehicles are currently for sale in California:[5]

- Ford F-150 bi-fuel pickup truck (California Department of Transportation has 700-800 of them, mostly fueled with gasoline, not LPG).

- General Motors (GM) medium-duty LPG truck (these have been available for about 10 years and California sales are estimated to total about 1,000 since 1998).

- Cummins B-Series engines, which can be used in pickups and shuttle buses.

- LPG-fueled GM shuttle van, which is just now entering the market, with GM taking orders but awaiting more before launching production (as of date written).

The industry hopes to sell about 200 LPG retrofit kits per year in California. Typical vehicle retrofit includes a 40 to 60 gallon tank (30 to 44 gallons gasoline equivalent) and vehicle refueling takes 3-5 minutes.

Assumptions

The staff evaluated the potential for using LPG to displace gasoline light-duty vehicles beyond those currently in use, assuming OEMs offer LPG as a factory option for new light-duty vehicles. The staff assumed existing federal LPG excise taxes (13.6 cents per gallon) and state LPG excise taxes (6.0 cents per gallon) continue, and calculated excise tax revenue lost to the government to determine total government costs.

LPG fuel sales volumes and prices peak in the wintertime for space heating, and a significant transportation use would tend to level these prices out. However, if the demand grows too rapidly, existing wintertime peak prices could intensify. This analysis assumes that growth in LPG use for transportation does not cause wintertime market price peaks to intensify because a long-term import market would be established.

The staff assumed that future LPG prices would be the same as gasoline prices on an energy equivalent basis. The staff used a low LPG price of $1.08 and a high price of $1.33, based upon an energy content of 82,485 Btu per gallon, lower heating value.[6] See Appendix A (Methodology) for a more detailed discussion of the methodology used for determining these prices.

Adding a 6,000-gallon underground LPG tank to an existing gasoline refueling station costs about $100,000.[7] Typical existing refueling station storage tanks are 500 to 1,000 gallons, but 30,000-gallon tanks are also in use. The staff assumed the price range indicated above provides sufficient margin to absorb this cost.

Light-duty LPG vehicles have been used successfully in California and elsewhere, although there are currently only a few medium-duty OEM vehicle offerings and no light-duty OEM vehicle or retrofit kit manufacturer suppliers. Staff assumed that government incentives are sufficient to induce retrofit kit manufacturers to certify their products for use in California to allow conversion of gasoline fueled vehicles in the 2008 time period. As OEM vehicle manufacturers see conversion kit sales increase, they make the decision to introduce new vehicles with an LPG option. The combination of retrofit kit and OEM offerings allows for vehicle deployment.

Historical vehicle conversion costs for light-duty vehicles were approximately $1,900 to $2,900 per vehicle (converted to 2001$). The staff assumed the higher value for the high end of the incremental capital cost estimate. In large volume OEM production, the staff expects the cost of making an LPG vehicle to be nearly the same as a gasoline vehicle, except the fuel storage costs would be about $200 more. This comprises the lower incremental capital cost estimate.

Results

The results of the staff analysis indicate that LPG vehicles can help to reduce gasoline consumption in California, as shown in Table 2E-1, whichare for the average fuel price of $1.64 per gallon and a range of liquefied petroleum gas and capital costs. More detailed results and discussions are located in Attachments A and B.

Table 2E-1. Gasoline Reduction from Liquefied Petroleum Gas (LPG)

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	31	1,111	2,327
Reduction From Base Case Demand (percent)	0.2	5.7	10.4

The cost-benefit results for Option 2E are shown in Table 2E-2. The net consumer benefit values indicate that consumers would have to absorb a monetary loss if an LPG vehicle was selected over a gasoline vehicle. The loss in net benefits increases in magnitude due to reduced collection of fuel excise taxes.

Table 2E-2. Direct Non-Environmental Benefits from Liquefied Petroleum Gas (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(22) – (1)	(0.1)	(22) – (1)
2002-2020	(1,254) – (43)	(10)	(1,264) – (52)
2002-2030	(3,753) – (111)	(32)	(3,786) – (144)
*Negative values are enclosed in parentheses.			

The benefit results show that this option would require an implementation strategy to provide additional positive consumer benefits to offset the estimated losses if LPG vehicles were to improve their market share and provide an incremental reduction in gasoline demand. Preferably, the additional benefits would make the net benefit positive, as well.

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- The availability of new OEM vehicles.

- The availability of CARB-certified retrofit kits for light-duty vehicles.

- Market forces must improve so that the incremental life cycle costs are sufficiently below that of a gasoline vehicle to re-stimulate this market.

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[1] *Alternative Fuels: Emissions, Economics, and Performance*, Society of Automotive Engineers, Inc., page 57.

[2] Information provided by Steve Moore of Mutual Liquid Gas, and compiled by A. D. Little for the CEC's *Clean Fuels Market Assessment, 2001*.

[3] U.S. DOE, Energy Information Administration website: [http://www.eia.doe.gov/cneaf/alternate/page/datatables/table1.html].

[4] U.S. DOE, Energy Information Administration, *State Energy Data Report for 1999* (latest available).

[5] "Personal Communication," Bill Platz, Delta Liquid Energy.

[6] An informal June 2002 survey of 12 retail stations led to a price range of $0.98 to $1.49 per gallon of LPG.

[7] *California Clean Fuels Market Assessment 2001*, California Energy Commission, P600-01-018 (September 2001).

Option 2F
Alcohol Fuels in Flexible Fuel Vehicles

Description

This strategy evaluates the potential to expand the use of alcohol based fuels in flexible fuel vehicles (FFVs).

Background

FFVs are capable of fueling with alcohol fuels (ethanol or methanol) in any combination with gasoline. While E85 and M85 are proven fuels in use today, other lower cost "FFV fuels" will likely emerge over time containing renewably based co-solvents and low value non-renewable blend stocks.

The current auto industry production of FFVs is stimulated by Corporate Average Fuel Economy (CAFE) credits created through the federal Alternative Motor Fuels Act of 1988 (AMFA). Manufacturers are entitled to a credit against their mandated average fuel economy for all vehicle sales for sales of FFVs. A maximum credit (or CAFE average addition) of 1.2 miles per gallon is allowable for any manufacturer, a "cap" that is statutorily scheduled to diminish to 0.9 miles per gallon as of the 2004 model year. While the FFV production levels equating with the above caps cannot be precisely calculated, a general estimate is that most manufacturers would reach the cap with production of 7 to 10 percent of their entire U.S. sales volume as FFVs.

To maintain current FFV production levels resulting from CAFE credits adopted through AMFA requires a commitment to expanded, sustained FFV production by the worldwide auto industry, most likely supported by government financial or regulatory inducements. Also, a fueling supply and infrastructure to make the use of alternative fuels in these vehicles practical and affordable would be needed and would require further initiatives and investments by the fuel suppliers, along with government inducements.

Status

All of the "big three" U.S. automobile manufacturers are currently building some models as standard production FFV models. California's vehicle population now includes an estimated 120,000 ethanol FFVs produced in the 1997 through 2002 model years. About 40,000 new ethanol FFVs per year are sold, representing about 2 percent of the state's new vehicle market. This fleet could grow to about 400,000 vehicles by 2010.

All FFV models currently produced are designed for ethanol in any combination with gasoline, up to 85 percent ethanol (E85). In past model years, FFVs designed for methanol and gasoline (up to M85) have also been produced and sold in California, with approximately 8,000 of these methanol FFVs estimated to be in operation still. While commercial FFV production to date has been limited to the big three U.S. manufacturers, eight other auto companies, including most of the major Asian and European auto makers, have provided pre-commercial FFV models for past

California demonstration programs. Thus, the industry-wide technological capability for expanded FFV production appears well within reach.

Furthermore, some FFV demonstration models have been built with both ethanol and methanol fueling capability, providing evidence that future FFV models could be produced that could use either of these alcohol fuels or even combinations of the two with gasoline. Other possible fuels for FFVs may also be developed. The “P-Series” fuel recently licensed to Pure Energy Corporation for commercial production and distribution provides one example. This fuel uses a combination of ethanol, co-solvents (potentially derived from waste biomass resources), natural gas liquids, and refinery pentanes (a rejected or “distressed” blend stock not suitable for use in summertime CaRFG3). This is an EPACT designated alternative fuel that, by definition, is substantially non-petroleum. The staff is unaware of any FFVs in California using something other than conventional gasoline.

Assumptions

While the outlook for FFV production and fueling is subject to speculation, two different scenarios extending through the year 2030 include the following:

- FFVs become 10 percent of the state’s light-duty vehicle population by 2020 and 30 percent by 2030. This is termed the Mature Market case and is evaluated in some detail.

- A “maximum achievable” scenario in which all new light-duty vehicles sold in the state become FFVs by 2017. This is termed the Ultimate Market case and is not evaluated in detail.[1]

The current California FFV population and annual sales trend was developed by the Energy Commission’s transportation modeling program based on analysis of Department of Motor Vehicles registration records. These current inroads for FFVs were expanded to construct three future scenarios as follows.

In the analysis, FFVs fueled with E85 are assumed to get 15.7 miles per gallon of E85,[2] while the average light-duty vehicle they would displace is assumed to get 21.2 miles per gallon of gasoline. While E85 fuel is the appropriate “FFV fuel” under high fuel price assumptions, a “Low Cost FFV Fuel” has been chosen as a more representative “FFV fuel” under low fuel price assumptions.[3] FFVs fueled with Low Cost FFV Fuel are assumed to achieve 18.8 miles per gallon rather than 15.7 miles per gallon because rejected gasoline and other blend stocks can be used in this fuel, which contains more energy per gallon relative to ethanol. Each fuel was assumed to increase fuel economy by 2.2 percent over the fuel economy expected solely from the energy content of the fuel. This factor occurs because ethanol in the fuel enhances combustion.

In a mature market, FFV production is assumed to lead to industry-wide levels that result in 10 percent of the state’s vehicle population comprised of FFVs by 2020, or about 3 million of the 30 million vehicles projected to be in use by that year. By 2030, the population increases to 30 percent of the FFV population, with FFVs accounting for 11 million of the state’s projected 36 million vehicles.

Gasoline displaced by FFV fuel is based on an assumption that they will use Low Cost FFV Fuel or E85 when they refuel. The amount of gasoline displaced is equivalent to the number of vehicles using Low Cost FFV Fuel 100 percent of the time, or using E85 fuel (High Fuel Price Case) 100 percent of the time. To be consistent with other Fuel Substitution options, the staff assumed only a limited number of vehicles would fuel with the FFV fuel, with conventional gasoline used the remainder of the time. See Attachment A (Methodology) for a discussion of vehicle deployment rate.

Results

Given the market conditions outlined above, FFVs can have a significant impact on the reduction of gasoline as shown in Table 2F-1. The results are expressed as a range due to different percentages of ethanol. See Attachments A and B for more detailed discussions.

Table 2F-1. Gasoline Reduction from Alcohol Fuels in FFVs

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	17 – 23	610 – 822	1,278 – 1,722
Reduction From Base Case Demand (percent)	0.1	3.1 – 4.2	5.7 – 7.7

The summary results of the cost-benefit analyses are shown in Table 2F-2. The range of direct consumer benefits show that in some cases consumers receive a monetary savings when selecting to use an ethanol and gasoline blended fuel (Low Cost FFV Fuel results) in an FFV. Government losses exceed consumer savings, for net losses.

Table 2F-2. Direct Non-Environmental Benefits from Alcohol Fuels in FFVs (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(1.0) – (0.1)	(13) – (3)	(14) – (3)
2002-2020	(49) – (11)	(991) – (239)	(1,040) – (250)
2002-2030	(133) – (36)	(3,338) – (806)	(3,471) – (843)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The following major factors that will determine the actual potential for FFVs to displace petroleum in California:

- Availability of E85 and other lower cost FFV fuels at fuel prices sufficiently below gasoline to cause consumers to seek out and use these fuels.[4]

- The federal government's action regarding continuing, revising, or rescinding the CAFE credit for production of FFVs.

- Possible emergence of other stimuli that may foster increased auto industry FFV production, including FFV offerings by foreign manufacturers and overall industry production at market penetration levels beyond those induced by the CAFE credits.

- FFV marketing decisions specific to California, including manufacturers electing to pursue emission certification and California marketing of all FFV models; also, the extent to which state and federal air quality regulatory approaches support (or accommodate) FFVs.

- The extent to which the above factors combine to produce a sufficient "critical mass" FFV population in the state to warrant necessary investments in fueling infrastructure by oil companies and independent distributors.

- The extent to which large fleet owners of FFVs (including both private fleets and publicly owned fleets such as the state government fleet) elect to lead the way by establishing E85 or other FFV fuel use practices

- Progress in the development of processes and projects for producing alcohol fuels, in-state, nationally, and internationally from cellulosic resources.

- The comparative market economics of ethanol and gasoline, as affected by government incentives and tax policies, including possible revision to the current federal tax incentives which provide greater market impetus for ethanol/gasoline blending than for E85 distribution.

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[1] Even though not formally evaluated, this scenario is quite feasible given the maturity and low costs of components required to make a vehicle an "FFV" when compared to all other options in the Task 3 analysis. This case would yield reductions in base case petroleum demand up to 81 percent (2030) assuming E85 as the FFV fuel of choice. Attachment C (Ethanol Demand and Supply Analysis) discusses sources of ethanol to meet demand implied in this option and Option 2G (Use of Ethanol in California Reformulated Gasoline). The analysis contained in the appendix indicates sufficient ethanol from a combination of in-state, Midwest, Pacific Northwest and foreign production to meet simultaneously the ethanol demand for both options. Volumes of ethanol required for an Ultimate Market case are shown to be possible for an E40 fuel that would roughly correspond to the Low Cost FFV Fuel analyzed under the mature market case. The analysis also shows that new ethanol production capacity would be required to meet the demand of the various cases.

[2] This FFV fuel is comprised of 85 percent ethanol and 15 percent CaRFG3.

[3] This FFV fuel is comprised of 30 percent ethanol, 35 percent non-petroleum or renewable blend stocks and 35 percent CaRFG3 and/or other low cost or rejected gasoline blending components.

[4] The economic analysis assumes fuel price parity on an energy equivalent basis.

Option 2G
Use of Ethanol in California Reformulated Gasoline

Description

This option addresses increased use of ethanol in California Phase 3 reformulated gasoline (CaRFG3).

Background

Under existing regulations, refiners can blend up to ten percent ethanol as a substitute for Methyl Tertiary Butyl Ether (MTBE). Initially, refiners are expected to blend 5.7 percent ethanol, as MTBE is phased out of gasoline by December 31, 2003. The option of 10 percent ethanol in gasoline is desirable from a petroleum displacement perspective, because a nominal 4.3 percent additional ethanol could be blended into the gasoline pool.

Currently, CaRFG3 requires a minimum of 5.7 percent by volume ethanol to meet a federally mandated 2-weight percent oxygen content requirement for federal non-attainment areas. Likewise, under current rules, refiners are allowed to use up to 3.7 weight percent oxygen corresponding to 10 volume percent when using ethanol. Blending at this volume yields the full value (i.e. 5.2 cents per gallon gasoline) of the 52 cent per gallon (ethanol blended) federal fuel excise forgiveness under federal tax law.

Status

Blending greater volumes of ethanol, up to a maximum of 10 percent ethanol by volume, is allowable under the CARB predictive model, but may cost more than a 5.7 percent ethanol in gasoline when ethanol is more expensive than gasoline or lower cost substitute hydrocarbons. If ethanol is available at lower cost than substitute hydrocarbons or gasoline, refiners will prefer to blend at 10 volume percent since this would lower the cost of making gasoline and increase margin.[1] To blend at 10 percent ethanol currently, refiners would have to change some fuel properties to offset emissions impacts associated with higher oxygen levels, to comply with the CaRFG3 predictive model emission performance criteria. This could decrease the volume of complying fuel produced and may require the refiner to blend at less than the desired 10 volume percent in order to achieve vehicle emissions no greater than those for the base case gasoline (CaRFG3).

Current emissions data for existing vehicle classes in the Air Resources Board's Predictive Model show that 10 percent ethanol blends would cause an increase of Oxides of Nitrogen (NOx), when compared to blends using 5.7 percent ethanol. In the existing model, adding oxygen to fuel tends to decrease carbon monoxide and hydrocarbon emissions but has the undesirable impact of increasing NOx emissions. It is possible that these effects could diminish as advanced technology vehicles are deployed in the fleet.

Assumptions

In this option, the term "5.7 percent ethanol" represents the expected practice of blending the minimum amount of ethanol required to meet requirements in regulations at the end of 2003. The term "10 percent ethanol" represents future potential practice of blending the maximum amount of ethanol allowed. The staff assumed that refinery economics remain favorable at 10 volume percent level and that emissions benefits of currently envisioned CaRFG3 using 5.7 percent ethanol are retained. Thus a nominal 4.3 volume percent increase in ethanol content is assumed for the analysis relative to the base case CaRFG3.

This analysis is limited to the petroleum reduction and cost impacts of a 10 percent ethanol blend, which might be possible at some future time. For purposes of this evaluation, the staff assumed that automobile manufacturers would continue to improve fuel systems and emission controls in passenger cars and light trucks consistent with emissions standards adopted under California regulations. Vehicles would need to drive and perform well on a CaRFG3 E-10 gasoline while achieving LEV II and post LEV II emissions standards. In addition, vehicle manufacturers would be expected to retain their current practice and warranty policy explicitly allowing use of 10 percent ethanol in gasoline.

To meet future state evaporative emission requirements automobile manufacturers are reducing evaporative and permeation emissions through the use of improved fuel system materials along with evolving emissions and flexible engine/fuel vapor control systems. These systems are anticipated to allow any level of oxygen in gasoline up to at least 10 percent ethanol content by volume. Thus, for this option, the staff assumed zero incremental vehicle capital cost associated with the use of E-10 CaRFG.

Regarding ethanol fuel supply to meet increased ethanol demand associated with 10 percent ethanol blending in California, the staff assumed that new ethanol plants would continue to be built in the United States in response to increased market demand. This demand is expected to increase, with the phase-out of MTBE nationwide and the establishment of a federal "renewable fuel standard," when and if enacted by Congress. A combined demand and supply analysis for ethanol can be found in Attachment C.

The staff estimates the cost to blend gasoline containing 10 percent ethanol to be the same as the cost to blend 5.7 percent ethanol in gasoline based on historical relationships of ethanol and gasoline prices. Ethanol prices are assumed to track gasoline prices, and a federal tax credit currently at 52 cents per gallon of ethanol blended (into gasoline) partially offsets the increased fuel cost to consumers. The federal tax credit shifts costs from consumers to the federal government. The staff further assumed that fueling, storage, and distribution infrastructure in place to serve a 5.7 percent blend market would be adequate to serve a 10 percent ethanol/gasoline market as well.[2] This cost analysis is conservative in that it does not reflect downward fluctuations in the market price of ethanol relative to gasoline, a recent trend which currently puts the cost of ethanol blending in gasoline lower than the cost of blending MTBE.[3]

This result presumes that the logistics of supplying 10 percent by volume ethanol are no greater a challenge than providing the expected 5.7 percent by volume ethanol. It also presumes that sufficient ethanol supply exists, and that the in-state logistics of ethanol transport and dispatching at the terminal rack for supplying 10 percent volume ethanol are accommodated in current planning for use of 5.7 percent ethanol in gasoline. We assume that the changeover to 10 percent occurs January 1, 2008.

Results

Tables 2G-1 and 2G-2 display the results of this analysis. Greater use of ethanol as an oxygenate in gasoline for conventional vehicles (moving from 5.7 percent up to 10 percent) is a fuel supply alternative that is especially sensitive to the fuel supply and price relationship used to forecast the base case gasoline demand. Without a usable estimate for the supply and price impact on base case gasoline due to this option, the end-use and demand-side methods used in this analysis can greatly under-predict the consumer benefit for this option. More detailed results and discussions are located in Attachments A and B.

Table 2G-1. Gasoline Reduction from Use of Ethanol in California Reformulated Gasoline

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	737	839	963
Reduction From Base Case Demand (percent)	4.3	4.3	4.3

Table 2G-2. Direct Non-Environmental Benefits from Use of Ethanol in California Reformulated Gasoline (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	0	(779)	(779)
2002-2020	0	(2,893)	(2,893)
2002-2030	0	(4,377)	(4,377)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

Major factors that will determine the actual potential for using increased volumes of ethanol to displace gasoline in California are as follows:

- The availability of ethanol to serve the increased demand without adversely impacting ethanol price and fuel prices.

- The willingness of auto manufacturers to continue to develop fuel and emission control systems that will allow operation at 10 percent ethanol in CaRFG3, while retaining desirable emissions and vehicle performance characteristics.

- The adoption of a federal renewable fuel standard, which would assure adequate supplies with minimal price volatility, as the in-state ethanol production industry develops.

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[1] Barber et. al., *Motor Gasolines Technical Review*, Document FTR1, Chevron Products Company, 1996.

[2] Discussions with several oil companies indicate that terminal storage of ethanol involves tanks sized to assure adequate inventories of ethanol given somewhat unpredictable movement of ethanol from the Midwest and the long transport distances involved. Future in-state ethanol production, combined with the excess ethanol inventory capability now in place for MTBE phase-out at the end of 2003, and assumed improvements in ethanol transport modes (e.g. unit trains) likely to occur in 2003 and 2004, is assumed to make 10 percent ethanol blending viable with no new capital cost expenditures.

[3] Contract ethanol delivered to California for June 2002 is estimated at about $1.15 per gallon. The federal fuel excise tax forgiveness (52 cents per gallon of ethanol) lowers the cost of ethanol to 63 cents per gallon for blenders (refiners). MTBE wholesale price as of June 2002 is about 97 cents per gallon and CaRFG wholesale price is about $1.00 per gallon.

Option 2H
Liquefied Natural Gas and Advanced Natural Gas Engines for Medium- and Heavy-Duty Vehicles

Description

In this option the staff explores a regulatory or incentive-based strategy intended to increase the use of natural gas in medium- and heavy-duty on-road vehicles.

Background

On-road medium- and heavy-duty vehicles are defined as vehicles with gross vehicle weight greater than 8,500 pounds. Expanded use of alternative fuels in medium-duty and heavy-duty trucks using more efficient, advanced natural gas engine technologies can reduce projected diesel fuel use from this sector. This option explores the use of compressed natural gas (CNG) in medium-duty vehicles and liquefied natural gas (LNG) or CNG in heavy-duty vehicles. Each would replace a vehicle normally fueled with diesel.

Medium-duty and heavy-duty trucks move much of the nation's goods and are considered vital to the economy. Because of the typical driving cycle of medium-duty trucks, usually intra-city or regional service, these vehicles can effectively use CNG when centrally refueled. Heavy-duty vehicles can also effectively use CNG in driving cycles similar to those for medium-duty vehicles. For intra- and interstate delivery routes, heavy-duty vehicles dominate transport service and require the greater range capability offered by LNG.

Natural gas medium- and heavy-duty vehicles are an attractive environmental option to diesel fueled vehicles because they emit fewer criteria pollutants and toxic components. The limited availability of refueling facilities and typically higher vehicle purchase prices have, however, affected the sale of this fuel option in these applications.

The staff limited this option to dedicated CNG and LNG vehicles in order to evaluate maximum diesel displacement. Dual fueled and bi-fueled vehicles would cost more to purchase as they have both a diesel and a CNG or LNG fueling system. Because they would use diesel, they would displace less diesel fuel. Furthermore, the staff assumed that in a mature market condition, as discussed below, the cost of using natural gas would be significantly less than the cost of using diesel.

Status

Some medium- and heavy-duty trucks use natural gas instead of diesel fuel. A small amount of pilot diesel fuel is used to initiate the combustion. Efforts are under way to limit the amount of pilot diesel fuel needed and to minimize emissions. Today's economics tend to favor diesel fuel and opportunities to use natural gas are limited. Municipal vehicles, including trash haul applications, street sweepers and utility trucks using natural gas have all been demonstrated.

Heavy-duty applications of natural gas include transport of goods by major store brands such as Raley's and Von's using CNG, and line-haul trucking such as Harris Ranch with LNG.

Natural gas and natural gas vehicle stakeholders have joined forces to establish two working groups to advance the state of natural gas heavy-duty vehicles. One is working to improve the vehicles and the other is working to improve fueling infrastructure.

The U. S. DOE and other stakeholders are working jointly to improve the performance of medium-duty and heavy-duty natural gas vehicle technologies.[1] Their near-term objective is to deploy one Class 3-6 vehicle by 2004 and one Class 7-8 vehicle by 2007, both of which will be designed to be commercially viable and meet year 2007 emissions targets while significantly advancing the performance capability of natural gas in these applications. Funding needs are $5 million in 2003 and 2004, decreasing annually to $1.25 million in 2007. They do not specifically identify efficiency targets. If funded, they expect that vehicles developed under this program will lead to commercial offerings that will achieve limited market scope with current incentive programs aimed at reducing emissions or displacing petroleum fuels.

Many of the same stakeholders are also involved in improving the refueling infrastructure in an effort to build the market for natural gas vehicles.[2] This effort focuses upon improved gas compression methods and component integration for compressed natural gas (CNG) and lowering the cost of liquefied natural gas (LNG) production by developing small-scale LNG production technology and lower cost equipment. Ensuring safety and reliability are important aspects of this work.

Assumptions

Diesel demand reductions in 2010, 2020 and 2030 from on-road heavy-duty vehicles are estimated based on projected sales of natural gas heavy-duty vehicles, associated improvements in advanced natural gas engine fuel economy, existing and projected vehicle populations, infrastructure costs, and other assumptions.

The staff determined weighted averages of the year 2000 vehicle fuel economies for the existing relevant diesel vehicle classes using several sources. In the analysis, the staff began with base case vehicles that achieve 12.5 miles per gallon of diesel in Class 3-6 vehicles and 6.5 miles per gallon of diesel in Class 7-8 vehicles. Fuel economies and vehicle miles traveled are weighted across vehicle classes.

All new natural gas vehicles sold by 2020 are fully competitive with conventional diesel vehicles on performance, reliability and durability bases, and meet prevailing emission standards. Compression ignition-based LNG vehicles meet prevailing fuel economy performance of diesel engines. Spark ignition-based CNG engine platforms meet 95 percent of prevailing diesel engine fuel economy performance, because of heavier on-board fuel tanks and throttling losses associated with spark ignition.

All new vehicles sold replace diesel-fueled vehicles because diesels dominate the vehicle population segment considered.

Variable penetration rates are used in all vehicle classes with higher rates in some classes and time periods than others.[3]

Certain costs are associated with achieving the assumed penetration rates and estimated petroleum displacements for NGVs. These include incremental capital cost, incremental fuel cost, and an incremental infrastructure cost.

The staff assumed that R&D successfully reduces incremental capital costs of medium-duty CNG vehicles from a high of $11,000 in 1997 to $2,000-$9,500 by 2030. Likewise, the staff assumed that R&D successfully reduces incremental capital cost of CNG Class 7-8 heavy-duty vehicles from a high of $45,000 in 1997 to $10,500-$20,000 by 2030. Similarly, the incremental capital cost of LNG Class 7-8 heavy-duty vehicles decreases from $28,767 in 1997 to $4,700-$17,000 by 2030. All are expressed in 2001 dollars. More detailed information is provided in Attachment A (Methodology).

Results

The use of CNG in medium and heavy-duty engines appears to approach consumer benefit parity with diesel engines in the long-term. Tables 2H-1 and 2H-2 display the results for direct Class 3-6 medium duty CNG vehicles. Tables 2H-3 and 2H-4 display the results for Class 7-8 heavy-duty CNG vehicles. Tables 2H-5 and 2H-6 display the results for class 7-8 heavy-duty LNG vehicles. Results are for the average diesel price of $1.65 per gallon and a range of natural gas and capital costs. More detailed results and discussions are located in Attachments A and B.

Table 2H-1. Diesel Reduction from Medium-Duty CNG Vehicles (Class 3-6)

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	2.5	13.8	18.3
Reduction From Base Case Demand (percent)	0.1	0.3	0.4

Table 2H-2. Direct Non-Environmental Benefits from Medium-Duty CNG Vehicles (present values, 2002 base year, 2001$, $1.65/gallon diesel)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(2.6) – (0.9)	(0.9)	(3.5) – (1.8)
2002-2020	(25.9) – (9.5)	(12)	(38) – (22)
2002-2030	(50.4) – (19.6)	(27)	(78) – (47)
*Negative values are enclosed in parentheses.			

Table 2H-3. Diesel Reduction from Heavy Duty CNG Vehicles (Class 7-8)

	Year		
	2010	**2020**	**2030**

Annual Reduction (millions of gallons)	16	88	117
Reduction From Base Case Demand (percent)	0.5	2.1	2.4

Table 2H-4. Direct Non-Environmental Benefits from Heavy-Duty CNG Vehicles (Class 7-8, present values, 2002 base year, 2001$, $1.65/gallon diesel)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(12) – (9)	(6)	(17) – (15)
2002-2020	(130) – (105)	(75)	(206) – (181)
2002-2030	(269) – (222)	(165)	(434) – (387)
*Negative values are enclosed in parentheses.			

Table 2H-5. Diesel Reduction from Heavy Duty LNG Vehicles (Class 7-8)

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	16	88	117
Reduction From Base Case Demand (percent)	0.5	2.1	2.4

Table 2H-6. Direct Non-Environmental Benefits from Heavy-Duty LNG Vehicles (Class 7-8, present values, 2002 base year, 2001$, $1.65/gallon diesel)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	2 – 5	(5)	(3) – 0
2002-2020	40 – 73	(67)	(26) – 6
2002-2030	101 – 163	(146)	(44) – 18
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- It is uncertain whether the fuel economy of natural gas vehicles can approach that of diesel fueled vehicles.

- It is uncertain that the efficiency of a natural gas engine could match that of a corresponding diesel engine.

- It is uncertain if the percentage of vehicles in each class will remain the same.

- It is uncertain whether vehicle miles traveled are the same for diesel and natural gas vehicles (affects demand reduction and incremental operating costs).

- It is uncertain whether a more rapid fleet turnover in the years 2015-2030 as vehicle fleet ages and replacement is justified by lower operating cost from more fuel-efficient vehicles.

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[1] Next-Generation Natural Gas Vehicle Program, Vehicle Working Group Workshop and Meeting, October 2001.

[2] Natural Gas Vehicle Infrastructure Working Group and Vehicle Working Group*, Summary of Recommendations to Overcome Natural Gas Vehicle Infrastructure Technology Obstacles*, September 2001.

[3] As used in this analysis, vehicle penetration rate means a percentage of new vehicles entering the existing fleet population. For this scenario, 100 percent of new vehicles sold meet the assumed fuel economy targets used in the analysis. It is estimated that new vehicle sales are fewer than 10 percent of the existing population in any given year. The penetration rate is varied to reflect rapid turnover of the vehicle population. A higher penetration rate is assumed to occur in the years 2015-2030 from aging and the availability of more fuel-efficient vehicles. A composite vehicle class distribution is used in estimating the vehicle penetrations.

Option 2I
Fischer-Tropsch Diesel

Description

In this option the staff considers the use of Fischer-Tropsch diesel (FT diesel) as a fuel extender in California diesel. FT diesel would be blended with EPA diesel to produce a diesel fuel meeting the same emission performance as the current California diesel specified by the California Air Resources Board (CARB). The blend of FT diesel and EPA diesel could then be sold as a CARB diesel fuel.

Background

FT diesel is made by using a catalyst to convert a feed gas, such as natural gas, into a synthetic diesel fuel. Recent advances in catalyst technology promise competitively priced FT diesel within the range of possible economic conditions found in the current California diesel fuel market.

FT diesel can be used directly in some existing stationary engines, and can be made compatible with light and heavy diesel engines for use in vehicles. Testing in unmodified diesel engines has shown reductions in hydrocarbons, carbon monoxide, NO_x, and particulate matter compared to California diesel fuel.[1]

Large quantities of remote natural gas, located too far from urban centers to be piped and used as a local fuel, are very attractive and economic sources of feed gas for producing FT diesel. Another potentially attractive source of feed gas is gas produced as a byproduct of oil recovery. FT diesel represents a beneficial supply alternative to conventional diesel fuel, or a blending component to produce greater volumes of low aromatic, lower sulfur diesel.

The nature of the remote location of feed stocks for FT diesel may be an issue, as they are the same geographical locations as imported crude oil. Importing large quantities of FT diesel may reduce the burden on petroleum diesel supplies, but they may face the same geographic and political issues as crude oil or refined products imported from those regions.

Status

Nearly every major oil company has announced plans to produce FT diesel. Several refiners used limited imports of FT diesel over the period from 1993 through 1998 to blend FT diesel with heavier, less desirable crude oil to make greater volumes of California's unique low-aromatic CARB diesel fuel.

The use of FT diesel is being driven by a need to produce a diesel fuel with lower aromatic content and higher cetane level. Regulations adopted by the CARB require that diesel fuel sold in California be limited to 10 percent by weight total aromatics (CARB diesel) or must meet an alternative formulation that produces equivalent emission benefits. Currently, all diesel fuel produced in California for in-state sale meets optional specifications for total aromatic content and cetane number in lieu of the uniform diesel aromatic content of 10 percent. With a sufficient price differential between CARB diesel and diesel produced for the rest of the U.S. (i.e., EPA diesel), FT diesel can be the most economical option to blend with EPA diesel to produce a CARB alternative formulation diesel.

According to the U.S. EPA, a diesel fuel formulated with FT diesel derived from natural gas would normally satisfy federal requirements for registration as a baseline diesel fuel.[2] Currently, there is no federal limitation on the amount of FT diesel that can be combined with petroleum diesel under the registration constraints.

Today, the major barrier to widespread use of FT diesel is its cost. At today's diesel prices, pure FT diesel (FT 100) costs about 10 cents more per gallon to produce, and retail prices are expected to be 15 to 25 cents per gallon higher than conventional, petroleum-derived diesel (CARB disel). New federal and state fuel specifications will likely increase the cost of conventional diesel. When compared to this higher cost reformulated diesel, the incremental price of FT diesel is expected to be 5 to 10 cents per gallon by 2006.

The potential worldwide availability of FT diesel over time has been projected from industry sources. These values are shown in Table 2I-1. Industry estimates of possible production sites using remote sources of natural gas could eventually more than double the volume shown in the table by 2007 and beyond.[3] Economic conditions at site specific locations and worldwide demand for synthetic fuels would control the pace of such development.

Table 2I-1. Projection of Worldwide FT Diesel Supply

Year	Volume Capacity	
	Barrels/Day	Gallons/Year, millions[a]
2002	152,000	2,202
2006	210,000	3,043
2007	338,000[b]	4,898

[a]Converted from barrels/day using 42 gallons/barrel and 345 full capacity days/year.
[b]This value could be 858,000 b/d if all potential Shell sites (eight 75,000 b/d units) being considered for 2007 prove to be feasible and are constructed. The value shown in the table assumes that one of these Shell facilities is constructed by 2007.

Assumptions

California's diesel fuel (CARB diesel) has more restrictive fuel quality specifications than federal diesel (EPA diesel). FT diesel can be blended with EPA diesel to produce a diesel fuel meeting CARB's requirements for an alternative diesel formulation.

The amount of FT diesel blended with EPA diesel is estimated from specifications for in-state diesel fuel that have been certified by CARB as an alternative diesel formulation. Typical values for the total aromatic content and cetane numbers for FT diesel and EPA diesel are shown in Table 2I-2. Based upon these specifications and a finished blended diesel with desired aromatic content and cetane number of 20 percent and 55, respectively, the ratio of FT diesel (FTD) needed to be blended with EPA diesel is 1:2 (one gallon of FTD is blended with 2 gallons of

EPA diesel). The resulting mixture can be called FTD33. The desired aromatic and cetane values are within the ranges for alternative diesel formulation specifications certified by CARB.[4]

If the suitable blending ratio of FT diesel to EPA diesel is 1:2, the value of FT diesel as a blending stock can be calculated from the sum of the wholesale price of EPA diesel and 3 times (a gallon of FT diesel can used to produce 3 gallons of CARB diesel) the price differential between CARB diesel and EPA diesel.[5] For this analysis, the calculated FT diesel value would have a range of $1.22-$0.90 per gallon (without taxes).

Table 2I-2. Diesel Fuel Specifications

Component	Percentage	Aromatic Content, %	Cetane No.	Wholesale Price/gallon, $
EPA Diesel	66.7	30	42.5	1.07-0.75
FT Diesel	33.3	0	80	1.21-0.85
Blended Diesel (FTD33)	100	20	55	1.12-0.78

The wholesale cost differential between FT diesel and CARB diesel is about $.10 per gallon. If CARB diesel is $0.96/gallon, FT diesel is then estimated to be $1.06 per gallon.[6] Because the blending value of FT diesel brackets this cost, FT diesel can be an attractive blending component to produce a CARB diesel formulation.

The staff examined the cost effectiveness of FT diesel under a mature market condition, which may very well be just emerging for this fuel. A present value calculation was performed on the incremental cost of using FTD33 over the life of a heavy-duty vehicle compared to the use of conventional CARB diesel. Vehicle life was assumed to be 16 years. There were no incremental costs related to vehicle acquisition or use or deployment of fueling infrastructure.

The analysis for a mature market assumes that the incremental retail cost of FT diesel is 5 to 10 cents per gallon higher than EPA diesel. The EPA diesel that would be blended with the FT diesel is assumed to be 5 cents per gallon lower than the cost of CARB diesel. A standard deviation in price of $.17 per gallon was used for high and low retail CARB diesel fuel prices.

Beginning in 2008, the use of FTD33 is ramped up to become the normal diesel fuel standard by 2019. At this future time, the entire diesel fuel supply sold in California becomes FTD33. Thus, in this scenario, one-third of the projected base case diesel demand would be met by FT diesel and the remaining balance provided by conventional petroleum diesel.

Results

The results show that under mature cost conditions for FT diesel and EPA diesel, the use of FT diesel to produce a compliant CARB diesel can be an attractive option for reducing demand for diesel and producing consumer savings. More detailed results and discussions are located in Attachments A and B.

Table 2I-3. Diesel Reduction from Fischer-Tropsch Diesel

	Year		
	2010	2020	2030
Annual Reduction (millions of gallons)	107	1,377	1,606
Reduction From Base Case Demand (percent)	3	33	33

Table 2I-4. Direct Non-Environmental Benefits from Fischer-Tropsch Diesel (present values, 2002 base year, 2001$, $1.65/gallon diesel)

	A	B	C (A+B)
Present Value Period	Direct Non-Environmental Consumer Benefits (million $)	Change in Government Revenue (million $)	Direct Non-Environmental Net Benefits (million $)
2002-2010	165	0	165
2002-2020	611	0	611
2002-2030	930	0	930

Key Drivers and Uncertainties

The projected demand for FT diesel depends on the following outcomes and assumptions:

- The worldwide production capacity for FT diesel must track the supply schedule shown in Table 2I-2. It is reasonable to assume that investment in additional production capacity is likely when crude oil prices are sustained at $20 per barrel or higher. The pace of investment would be higher at higher oil prices.

- FT diesel would preferentially flow to California if its value were sufficiently attractive for distributors and refiners. Although the analysis did not assume the use of financial incentives to produce a competitive price for FT diesel, its use by those producing a diesel fuel for California could be enhanced by reducing the state's fuel excise tax. If the excise tax for diesel fuel made with 33 percent FT diesel was reduced by $.01 per gallon, the cost of FTD 100 for blenders would effectively be reduced by $.03 per gallon. This might give refiners a sufficient economic advantage to use FT diesel as a preferred blending agent to produce a diesel fuel meeting California's alternative diesel formulation requirements. Although such action would reduce the projected net benefit for this option, the magnitude of the excise tax reduction could be sized at a level that would not erode the entire value of positive net benefit.

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[1]Durbin, T. D., et.al., *Evaluation of the Effects of Alternative Diesel Fuel Formulations on Exhaust Emissions Rates and Reactivity*, Final Report, Center for Environmental Research and Technology, University of California, Riverside, CA, April 1999, [www.cert.ucr.edu/research/pubs/99-ve-rt2p-001-fr.pdf].

[2] "Personal Communication" (e-mail) with Jim Caldwell, U.S. EPA, June 20, 2002. Baseline Diesel Requirements contained in Title 40 CFR 79.56(e)(3)(ii)(A).

[3] Hart Gas-to-Liquids News, Hart Publications, June 2003, page 9. Plant capacities for existing, under construction, and under development plants, and plant feasibility studies with specific data and dates were used to project supply. Capacities listed in the table originate from the distillate fraction of output streams rounded to the nearest thousand units (barrels per day). The fraction is assumed to be 70 percent of total plant capacity.

[4] [www.arb.ca.gov], Certified Alternative Diesel Formulations, February 2002.

[5] Example calculation for the value of FT diesel: Wholesale price of EPA diesel = $0.75/gallon, wholesale price of CARB diesel = $0.80/gallon, 1:2 blend ratio of FT diesel to EPA diesel; value of FT diesel = $0.75 + ($0.80 - $0.75)(3) = $0.90/gallon.

[6] The wholesale price of CARB diesel is derived from the long-term retail price used in the base case demand analysis, $1.65 per gallon. The retail price results from a (wholesale price + retail margin + federal excise tax + state excise tax) x (state sales tax rate). The wholesale price would include margins for producing and distributing the fuel to consumers, $.15 per gallon. The federal and state excise taxes for diesel fuel are $0.243 and $0.18 per gallon, respectively. A state sales tax rate of 7.75 percent was employed.

Option 2J
Biodiesel

Description

This option evaluates the use of biodiesel fuel in two formulations as a fuel extender for California diesel fuel. One employs biodiesel as a lubricity agent in a 2 percent by volume blend (B2) with California diesel. The second formulation is a B20 blend (a 20 percent by volume biodiesel blend with California diesel) for use in heavy-duty vehicles.

Background

Biodiesel fuels are typically made from soybean oils, rapeseed oil, animal fats or recycled cooking greases. Biodiesel is made by reacting any natural oils or fats with alcohol (usually methanol). It can be used in neat form (B100) or as a blendstock to extend the supply of conventional, petroleum-derived diesel (used at a 20 percent biodiesel to 80 percent conventional diesel, it is called B20). Using 2 percent by volume biodiesel (called B2) blended into conventional, petroleum-derived diesel can provide an alternative fuel lubricity option.[1]

Biodiesel has low sulfur levels, typically lower than 2006 federal sulfur requirements, and can be used as a blendstock to reduce the overall sulfur content of some diesels. Biodiesel can be used in most applications in the same manner as conventional petroleum diesel. One notable exception is that special handling and heaters may be required in cold weather applications. Also, there may be some materials compatibility issues with seals and gaskets in engines manufactured before 1994. At the present time, the practice is to limit the percentage of biodiesel to no more than 20 percent (B20) to avoid these problems.

When blended at 20 percent with conventional diesel fuel, the resultant mixture has generally demonstrated lower or comparable emissions of total hydrocarbons, carbon monoxide, and particulate matter compared to CARB diesel.[2] The emission level for NO_x is comparable to the level for CARB diesel[2] or slightly higher.[3,4] The range in emission levels seems to vary, depending on the type of feedstock used to produce the biodiesel and the quality of the petroleum diesel used in the mixture.

Neat biodiesel (B100) has a lower energy content than conventional diesel. The energy content (lower heating value) of biodiesel ranges from about 117,000 to 124,000 Btu per gallon[5] while conventional CARB diesel fuel is about 127,500 Btu per gallon.

The U.S. DOE's Office of Transportation Technologies has estimated the net energy balance for biodiesel. For every gallon of petroleum fuel used to produce it, 3.37 gallons of biodiesel are produced.[6]

Status

The supply of biodiesel is limited today by its significantly higher production cost. When used in its pure form (B100), biodiesel costs between $1.25 and $2.25 per gallon depending on purchase volume and delivery costs.[7] Presently, B20 costs 13 to 22 cents per gallon more than petroleum diesel.[8] However, federal legislation, H.R. 4843 (Hulshof), has been introduced to provide a $0.01 per gallon reduction in fuel excise tax for each percentage point of biodiesel used to blend in diesel fuel, up to a limit of 20 percent. If enacted, this legislation would effectively reduce the cost of B100 for blenders by up to $1.00 per gallon. Because this is pending legislation at this time, this effect was not included in the analysis reported below.

The U.S. DOE is conducting research to reduce the cost of producing biodiesel and to expand supplies using novel feed stocks and new production technologies. A portion of the work is directed at reducing NO_x emissions.

The projected national supply of biodiesel is shown in Table 2J-1.

Table 2J-1. Projected Biodiesel Supply[9]

Year	Volume (millions of gallons)
2002	4
2010	1,000
2020	6,000

Assumptions

Two biodiesel scenarios are examined. The cases separately assume that B2 and B20 become an industry standard for California diesel fuel. The amount of biodiesel used in any given year is assumed to be limited to a maximum of 10 percent of national biodiesel supply. In the first case, 2 percent biodiesel is blended with CARB diesel (called B2) as a lubricity additive, beginning in 2008. In the second case, biodiesel is used as a blending agent to extend CARB diesel supplies, beginning at 2 percent blending rate in 2008 and gradually increasing to 20 percent by 2015. In the earlier years, the national supply of biodiesel may limit the volume that could be used as a blending agent, although supplies should be sufficient for the full 20 percent blending rate by 2015.

Because biodiesel can be used in existing diesel engines without modification at levels of B20 and below, there is no incremental cost related to vehicle purchase. The existing diesel fuel infrastructure can also store and dispense B20 without modification.

In this analysis, the staff used literature estimates of the cost of biodiesel, and determined the cost of B2 and B20 by ratio. For the near term analysis the staff used B2, with a neat biodiesel (B100) wholesale price range of $1.25 to $1.75 (includes a delivery charge of $0.04 per gallon).[10] For the mature technology analysis the staff used B20, with a mature market neat biodiesel (B100) wholesale price of $1.25 (includes the same delivery charge). These costs resulted in B2 wholesale prices about $0.01 $0.02 per gallon greater than CARB diesel and B20 prices about $0.02 to $0.08 per gallon greater than CARB diesel. The lower heating value staff used for B100 varies depending on the type of biomaterial used. The staff used a midpoint value of 121,000 Btu/gallon.

A mature market scenario is used to model the use of biodiesel at up to a 20 percent blend level in CARB diesel. The scenario assumes that 10 percent of the projected national supply of B100 would be used to gradually increase the amount of biodiesel blended with petroleum diesel until B20 becomes a statewide, industry standard.

This scenario calculates the incremental cost of B20 based upon a B100 wholesale cost of $1.25 per gallon. It would then be blended with a CARB diesel fuel. The estimated B20 wholesale price range is about $0.88 to $1.13 per gallon. A standard deviation in price of $.17 per gallon was used for high and low retail diesel fuel prices. No incremental costs are assumed to be required for vehicle acquisition or fuel infrastructure.

Results

Tables 2J-2 and 2J-3 display the results for diesel reduction from B2. As an alternative fuel lubricity option, B2 can offer some benefits in the intermediate market with modest consumer costs. Tables 2J-4 and 2J-5 display the results for B20 as a blended diesel fuel. More detailed results and discussions are located in Attachments A and B.

Table 2J-2. Diesel Reduction from B2 (Lubricity Option)

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	72	83	97
Reduction From Base Case Demand (percent)	2	2	2

Table 2J-3. Direct Non-Environmental Benefits from B2 Lubricity Option (present values, 2002 base year, 2001$, $1.65/gallon diesel)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(75)	0	(75)
2002-2020	(285)	0	(285)
2002-2030	(434)	0	(434)
*Negative values are enclosed in parentheses.			

Table 2J-4. Diesel Reduction from B20 (CARB Diesel Blending Agent)

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	102	800	933
Reduction From Base Case Demand (percent)	2.7	19.4	19.4

Table 2J-5. Direct Non-Environmental Benefits from B20 CARB Diesel Blending Agent (present values, 2002 base year, 2001$, $1.65/gallon diesel)*

	A	B	C (A+B)
Present Value Period	Direct Non-Environmental Consumer Benefits (million $)	Change in Government Revenue (million $)	Direct Non-Environmental Net Benefits (million $)
2002-2010	(424)	6	(418)
2002-2020	(1,773)	128	(1,645)
2002-2030	(2,762)	286	(2,476)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- Although the projected supply of biodiesel appears sufficient, demand in other regions of the country would have to increase to support the required investment in production capacity.

- The long-term production cost of biodiesel is expected to decrease as production technology improves, lower cost feedstocks are developed, and production scale-up reduces unit costs.

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[1] U. S. DOE, Office of Transportation Technologies, [http://www.ott.doe.gov/biofuels/renewable_diesel.html].

[2] Thomas D. Durbin, et. al., Final Report, *Evaluation of the Effects of Biodiesel and Biodiesel Blends on Exhaust Emission Rates and Reactivity-2*, Center for Environmental Research and Technology, College of Engineering, University of California, Riverside, CA, August 2001.

[3] Clark, N.N., et al., *Transient Emissions Comparisons of Alternative Compression Ignition Fuels*, West Virginia University, submitted to 1999 SAE Congress.

[4] Starr, M.E., *Influence on Transient Emissions at Various Injection Timings, using Cetane Improvers, Biodiesel, and Low Aromatic Fuels*, 1997, SAE Technical Paper No. 972904.

[5] U.S. DOE, Alternative Fuels Data Center, [http://www.afdc.doe.gov/altfuel/bio_papers.html], May 2002; The stated range comes from different rounded values published in papers found at this website.

[6] U.S. DOE, Office of Transportation Technologies website, "Biodiesel Benefits."

[7] U.S. DOE, Clean Cities Alternative Fuel Information Series, Fact Sheet, May 2001.

[8] Ibid.

[9] Supply projections based upon staff communication between Gary Yowell and Dr. K. Shaine Tyson, National Renewable Energy Laboratory, August 2001.

[10] The charge for tank truck delivery varies by delivery distance: for an 8,000 gallon load, $0.015/gal for 10 miles, $0.0252 for 40 miles, $0.0404 for 100 miles, $0.0698 for 250 miles (personal communication between Alan Argentine and Redwood Oil Company, Santa Rosa, CA, July 2002); an average of $0.04/gal is used in this analysis.

GROUP 3
PRICING OPTIONS

Option 3A
Gasoline Tax

Description

In this option the staff examines the effect of increasing the tax on gasoline in California by 50 cents per gallon for the period 2003-2030.

Background

A higher gasoline tax would reduce the consumption of gasoline through two mechanisms. First, the additional tax would increase the per-mile cost of driving, reducing vehicle miles traveled. Second, the tax would provide an incentive for vehicle owners to purchase a more fuel-efficient vehicle, as this would reduce exposure to the tax. This second mechanism, which would take place over time, would lead to greater reductions in gasoline demand in the medium and long term relative to the short term.

Status

Current gasoline excise taxes (state and federal) amount to around 36 cents per gallon in California. When proposals have been made in California and other states for an increase in fuel taxes, the higher tax is meant as a funding mechanism, usually for transportation related projects. The staff is not aware of any serious attempt by policymakers in the U.S. to increase fuel taxes for purposes of reducing gasoline consumption since the carbon tax proposal during the first term of the Clinton administration.

Assumptions

The Commission's CALCARS model was used to simulate this option. CALCARS is a behaviorally-based vehicle choice, usage, and demand model estimated specifically for California. The model predicts at the household level, using 57 types of households that vary by annual income, number of members, and number of employed members.

The price of gasoline was increased by 50 cents, and this increase affected miles driven, vehicle choice, and vehicle demand. The higher gasoline tax was assumed to affect personal vehicles only, as the models used by the Commission for commercial fleet and freight energy demand are currently not behaviorally based.

Results

Table 3A-1 displays the results for gasoline reduction from a gasoline tax as described above. More detailed results and discussions are located in Attachments A and B.

Table 3A-1. Gasoline Reduction from Gasoline Tax

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	745	892	1,051
Reduction From Base Case Demand (percent)	4.6	4.8	4.9

Table 3A-2 shows the net benefit results for consumers and the impact on government revenues (in this case a positive net benefit), in present value terms, for 2010, 2020, and 2030, for a 5 percent discount rate. These calculations are net amounts relative to the base case forecast. The negative consumer benefits (also known as the change in consumer surplus) are equal to the higher cost per gallon of gasoline times the new (lower) level of gasoline demand, plus a "deadweight" loss to society. The deadweight loss is composed of the lost benefits to motorists due to reduced driving and the costs to those who switch to a less-preferred (more fuel-efficient) vehicle.

Government revenues increase by the new (lower) level of gasoline consumption times 50 cents, plus the reduction in the cost of highway maintenance (the decrease in VMT times 0.4 cents), minus the excise tax revenues lost due to decreased gasoline consumption. The sum of these impacts, plus reduced ethanol subsidy payments, is shown in Table 3A-2 as "Direct Non-Environmental Net Benefits," and represents direct benefits excluding the "external" beneficial effects of reduced driving and gasoline demand (e.g., less congestion, less gasoline-related pollution). These entries are negative, but once environmental effects are considered, total direct benefits may be positive.

Table 3A-2. Direct Non-Environmental Benefits from 50 Cent Higher Fuel Tax (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(38,156)	36,247	(1,909)
2002-2020	(73,599)	69,804	(3,795)
2002-2030	(98,478)	93,324	(5,154)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- The future price of gasoline would play a key role in the impact of a higher gasoline tax. If gasoline prices are significantly higher than what is projected in the base case forecast, the impact of a higher tax on gasoline demand would be reduced, since discretionary driving (the first type of driving to be affected by higher gasoline prices) would already be at a lower level.

- Long-run price elasticities (as vehicle owners purchase more fuel efficient vehicles over time) are higher in absolute magnitude, although at the lower end of the range estimated in the literature. This is partly due to the assumption made for this analysis that manufacturers offer the same fleet mix in California relative to the base case forecast. If manufacturers were to respond by offering vehicles with additional fuel economy technologies, long-run price elasticities would be higher. It is quite possible that there would be additional effects not captured by CALCARS. In the long term, households may respond to higher gasoline prices by changing location (e.g., to be closer to transit or to reduce work commute miles) and government may be more likely to push/promote land use policies that reduce travel costs (e.g., transit oriented development). Such effects would lead to further decreases in travel and fuel use.

Option 3B
Marginal Cost Pricing for Auto Insurance

Description

In this option the staff examines the effects of implementing a "pay-at-the-pump" (PATP) auto insurance system, where a portion of insurance is paid through a fuel surcharge, and a "pay-as-you-drive" (PAYD) system, where a portion of insurance is paid through a per-mile charge.

Background

In recent years, PATP and PAYD insurance have attracted a great deal of attention as alternatives to the current auto insurance market. PATP insurance proposals require that at least some portion of auto insurance be covered through a higher fuel tax, with the rest paid either as an increment to registration fees or directly to an insurance company. PATP is touted as a money saver for currently insured motorists, since uninsured motorists would have to pay at least some insurance (through the fuel surcharge), so that uninsured motorist coverage now paid by insured drivers would be reduced or eliminated.

PAYD insurance proposals involve a per-mile charge that would be paid directly to auto insurance companies. In practice, PAYD would likely require premiums to be paid in advance (as is the case under the current system), with vehicle owners either paying an additional amount per billing period or receiving a rebate, depending on vehicle miles traveled (VMT).[1]

An appealing aspect of both PATP and PAYD is that these measures would more closely link the cost of insurance to VMT. The more miles driven, all else equal, the greater the exposure to accidents. The current system of pricing is inefficient since insurance is perceived by motorists as a fixed cost, whereas it is quite likely that at least a portion of accident risk is a variable component related to VMT.[2] Through more efficient pricing of insurance, therefore, PATP and PAYD have potential welfare benefits.

Because PATP and PAYD insurance would increase the marginal cost of driving, VMT and gasoline use should decrease, since many motorists would likely drive less. In addition, in the case of PATP, many motorists would switch to a more efficient vehicle to reduce exposure to the higher tax (either within the household's current fleet or through replacement of a currently held vehicle), so that average vehicle fuel economy would increase. PATP and PAYD act as travel demand measures, therefore, and external costs related to both driving (e.g., congestion) and gasoline use (e.g., global warming) would be expected to fall. Furthermore, these benefits may not require an increase in private costs for the average motorist.

Status

PATP generated quite a bit of interest in California in the early 1990's, and legislation was drafted to examine its workability. Since then, no serious attempt has been made by policymakers in the U.S. to implement a PATP system. PAYD has generated enough interest that the Federal Highway Administration's Value Pricing Program funded two PAYD pilot projects in fiscal year 2001.

Assumptions

The Commission's CALCARS model was used to simulate this option. CALCARS is a behaviorally-based vehicle choice, usage, and demand model estimated specifically for California. The model predicts at the household level, using 57 types of households that vary by annual income, number of members, and number of employed members.

In this analysis, the minimum amount of liability insurance required by California law is paid through a fuel surcharge, beginning in 2003. Vehicle fixed costs are therefore reduced while marginal costs increase. In previous work, the cost for this minimum amount of insurance was estimated to be between $150 and $400 in California, depending on the insurance company and the geographic area.[3] In this simulation, the staff assumed the cost to be $250 in 2003. This translated to roughly 2.1 cents per vehicle mile traveled by personal vehicles, collected through a gasoline surcharge in the case of PATP and through a rebate/additional fee system in the case of PAYD.

The PATP incentive to drive/purchase a more fuel-efficient vehicle increases average fuel efficiency from year to year, effectively reducing the amount collected per mile. It was necessary, therefore, to increase this surcharge slightly every year to keep the amount collected per mile constant, from 44 cents per gallon at the beginning of the forecast period to almost 45 cents by 2030. At the same time, fixed costs per vehicle were reduced by $250 in 2003, adjusted upward slightly through the forecast period as VMT per vehicle increased.[4] Note that the critical assumption that must be made is that the portion of accident risk transferred to a marginal cost is proportional to VMT.

Because law requires it, the staff assumed that all drivers in California would carry minimum insurance without PATP or PAYD.

The staff assumed that PATP would affect personal vehicles only because the models used by the Energy Commission for commercial fleet and freight energy demand are currently not behaviorally based.

Results

Gasoline demand reductions relative to the base case forecast are greater for PATP than for PAYD because of the incentive that PATP creates to drive more fuel-efficient vehicles. Because of this incentive, percentage reductions in gasoline demand from PATP increase over time (unlike PAYD) and percentage reductions in VMT (not shown) are smaller than those for gasoline demand.[5]

Because the average increases in operating cost and decreases in fixed cost are the same for PATP and PAYD, net consumer benefits are virtually identical. The gain in economic efficiency predicted by economic theory is reflected in the positive net benefits for consumers shown in the tables. These benefits are a net of the reduction in direct payments to insurance companies and the burden of higher operating costs. The average motorist now incorporates accident risk in his marginal driving decisions and is able to reduce his total cost of insurance by driving less—an option not available without marginal cost pricing of insurance. On a per-vehicle basis, net consumer benefits from PATP and PAYD average between $3 and $4 per year.

Tables 3B-1 and 3B-2 display the results for gasoline reduction from pay-at-the-pump auto insurance. More detailed results and discussions are located in Attachments A and B.

Table 3B-1. Gasoline Reduction from Pay-at-the-Pump Auto Insurance

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	610	739	879
Reduction From Base Case Demand (percent)	3.8	4.0	4.1

Table 3B-2. Direct Non-Environmental Benefits from Pay-at-the-Pump Auto Insurance (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	523	(902)	(379)
2002-2020	1,006	(1,862)	(856)
2002-2030	1,348	(2,575)	(1,227)
*Negative values are enclosed in parentheses.			

Tables 3B-3 and 3B-4 display the results for gasoline reduction from pay-as-you-drive auto insurance. More detailed results are located in Attachment B.

Table 3B-3. Gasoline Reduction from Pay-as-you-Drive Auto Insurance

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	459	519	594
Reduction From Base Case Demand (percent)	2.8	2.8	2.8

Table 3B-4. Direct Non-Environmental Benefits from Pay-as-you-Drive Auto Insurance (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	522	(693)	(171)
2002-2020	1,004	(1,328)	(324)
2002-2030	1,346	(1,771)	(425)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- The responsiveness of motorists to higher operating costs will determine the magnitude of net consumer benefits for PATP and PAYD. The more responsive are drivers, the higher the level of net consumer benefits (and the higher the reduction in VMT and gasoline use). However, if we assume all motorists carry minimum insurance in the base case forecast, consumer net benefits will always be positive, given the assumptions made here (they would be zero if there were absolutely no response to higher operating costs). That is, the average consumer will always be better off. Of course, this does not mean that every motorist would be better off. Those who drive many more miles than the average could end up with higher insurance costs and, under PATP, drivers of vehicles with very low fuel efficiency could be adversely affected, unless a mechanism were implemented to address differences in fuel efficiency.

- If we allow for the possibility that there could continue to be a significant number of uninsured drivers in California, it is likely that PATP would have even more favorable welfare impacts for insured motorists. The fuel surcharge would force uninsured drivers to pay at least some of the costs that they impose on the insured. The current charge for uninsured motorist coverage that is part of liability insurance could then be reduced or eliminated. On the other hand, such a system would have adverse welfare impacts for uninsured drivers.

- A PAYD system has advantages over PATP because of its flexibility. The amount charged per mile could be varied by insurance companies depending on specific customer characteristics and/or on the type and amount of auto travel. In addition, unlike PATP, PAYD would not penalize owners of less fuel-efficient vehicles (although PATP could be set up to avoid such an inequity through fees and rebates). PAYD also avoids the need to address complications such as out-of-state motorists and potential adverse impacts on the California economy created by higher gasoline prices.

- In this analysis the staff assumes a risk cost transferred to vehicle operating cost of 2.1 cents per mile throughout the forecast period. At present, there is no definitive empirical work available to justify any specific cost per mile (although it is certainly greater than zero), and such work would be required before PATP or PAYD could be implemented. This is a key point to emphasize. Charging an amount per mile different from the true marginal cost per mile could lead to an even more economically inefficient system than what we currently have. In addition, even assuming that 2.1 cents is a reasonable estimate at the present time, this value could certainly decrease in the future as autos continue to become safer. If this were the case, the net benefits presented here, as well as the reductions in gasoline demand and VMT, would be overstated (although still positive).

[1] For a further description of implementation, see: Litman, Todd (1997), "Distance-based Vehicle Insurance as a TDM Strategy," *Transportation Quarterly* (51:3).

[2] Insurance companies do currently charge higher premiums for relatively high-VMT drivers to some extent. However, the steps over which the premium remains constant are extremely wide. In addition, insurance companies have no way of ensuring higher premiums for such drivers, since they now depend on the insured to report estimated miles traveled.

[3] Kavalec, C., and J. Woods (1999), "Toward Marginal Cost Pricing of Accident Risk: the Energy, Travel, and Welfare Impacts of Pay-at-the-Pump Auto Insurance," *Energy Policy* (27:6).

[4] The risk cost per mile, 2.1 cents, was assumed constant throughout the forecast period. As income per household is projected to increase, VMT per vehicle increases slightly. Therefore, the fixed cost reduction was increased from $250 to a maximum of $255 to account for the increase.

[5] This result represents a rebound effect. The switch to more efficient vehicles reduces the impact of higher gasoline prices on vehicle fuel cost per mile.

Option 3C
Tax on Vehicle Miles Traveled

Description

In this option the staff looks at the effect of implementing a tax on vehicle miles traveled (VMT) in California of 2 cents per mile for the period 2003-2030.

Background

A tax on VMT would reduce driving and therefore gasoline demand. Unlike a higher tax imposed on gasoline, however, a VMT tax does not create an incentive to switch to a more fuel-efficient vehicle to reduce exposure to the tax. In this sense, such a tax is less effective in reducing gasoline demand than a higher gasoline tax.

An obvious hurdle to implementing a VMT tax is collection. A system would have to be developed to collect the fees in as unobtrusive a manner as possible while minimizing possible fraud. Such a tax would likely have to be collected more than once a year so that motorists make the connection between driving and a higher cost of driving; an annual collection might make the connection too remote.

Status

There are currently no serious proposals for per-mile charges in the U.S., aside from those related to pay-as-you-drive auto insurance. See Option 3B (Marginal Cost Pricing for Auto Insurance) for more information.

Assumptions

The Commission's CALCARS model was used to simulate this option. CALCARS is a behaviorally-based vehicle choice, usage, and demand model estimated specifically for California. The model predicts at the household level, using 57 types of households that vary by annual income, number of members, and number of employed members.

The per-mile cost of driving was increased by 2 cents, and this increase affected annual miles driven as well as vehicle demand.[1] Vehicle choice was not affected since the per-mile fee would be the same no matter what type of vehicle was chosen (unlike a higher gasoline tax). The VMT tax was assumed to affect personal vehicles only, as the models used by the Commission for commercial fleet and freight energy demand are currently not behaviorally based.

Results

Table 3C-1 displays the results for gasoline reduction from a tax on vehicle miles traveled. Unlike the higher gasoline tax option (Option 3A), the annual percentage decrease in gasoline demand is projected to remain relatively constant, since the VMT tax creates no incentive to purchase a more fuel-efficient vehicle. More detailed results and discussions are located in Attachments A and B.

Table 3C-1. Gasoline Reduction from Tax on Vehicle Miles Traveled

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	487	550	631
Reduction From Base Case Demand (percent)	3.0	2.9	2.9

Table 3C-2 shows the net benefit results for consumers and the impact on government revenues (in this case a positive net benefit), in present value terms, for 2010, 2020, and 2030, for a 5 percent discount rate. These calculations are net amounts relative to the base case forecast. The negative consumer benefits (also known as the change in consumer surplus) are equal to the higher cost per mile times the new (lower) level of VMT, plus the lost benefits to motorists due to reduced driving (known as the "deadweight" loss to society).

Government revenues increase by the new (lower) level of VMT times two cents, plus the reduction in the cost of highway maintenance (the decrease in VMT times 0.4 cents), minus the excise tax revenues lost due to decreased gasoline consumption. The sum of these two impacts is shown as "Direct Non-Environmental Net Benefits" in Table 3C-2, and represents direct benefits excluding the "external" beneficial effects of reduced driving and gasoline demand (e.g., less congestion, less gasoline-related pollution). These entries are negative, but once environmental effects are considered, total direct benefits may be positive.

Table 3C-2. Direct Non-Environmental Benefits from Tax on Vehicle Miles Traveled (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	(32,560)	31,231	(1,329)
2002-2020	(62,868)	60,334	(2,534)
2002-2030	(84,295)	80,917	(3,378)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- The key driver for the results described above is the response by households to driving costs predicted by the CALCARS model. The price elasticity of vehicle miles traveled (that is, the percent change in VMT due to a one percent change in driving cost per mile) endogenous to the model is consistent with most other empirical work.

- It is quite possible that there would be additional effects not captured by CALCARS. In the long term, households may respond to the higher cost of driving by changing location (e.g., to be closer to transit or to reduce work commute miles) and government may be more likely to push/promote land use policies that reduce travel costs (e.g., transit oriented development). Such effects would lead to further decreases in travel and fuel use.

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[1] The choice of 2 cents per mile was somewhat arbitrary—an amount that promised to have a significant effect on gasoline demand but not so high as to create an onerous financial burden for motorists.

Option 3D
Feebates

Description

In this analysis the staff looks at the effect of implementing a system of fees and rebates ("feebates") in California for 2003-2030 for new light-duty vehicles to encourage the purchase of more efficient vehicles. The analysis examines two cases. The first case includes a feebate program for California only (state feebate), which includes a limited response (in terms of adding additional fuel economy technologies to new cars and light trucks) by auto manufacturers. The second case includes a nationwide feebate system, with a full response by manufacturers.

Background

Feebates are a combination of fees and rebates. Feebates are targeted to the sale of new personal vehicles, based on fuel efficiency or emissions of carbon. The analysis presented here examines the effects of a feebate system based on carbon emissions. Vehicles emitting relatively low levels of carbon receive rebates while their high carbon emitting counterparts pay fees. Such a feebate system is also a means of improving fleet average fuel efficiency and therefore reducing overall gasoline consumption, since low-mileage gasoline vehicles emit more carbon per mile.

For this analysis, feebates are structured so that the net feebate receipts of the government are zero; that is, to achieve "revenue neutrality." The fees paid to the government exactly offset the rebates paid by the government on the sales of favored vehicles. The feebate system has a zero point, or "carbon threshold." The threshold is the carbon emissions level at which vehicle purchasers neither receive a rebate nor pay a fee. Those that exceed the threshold, high-carbon vehicles, pay a fee to government. The revenues are used to provide a rebate to those who buy a vehicle that emits below the threshold, a low-carbon vehicle.

For purposes of this analysis, feebates affect consumer welfare in four ways.[1] First, feebates act as a system of taxes and subsidies, which create what economists call a "deadweight" loss to society.[2] Second, the average vehicle owner benefits from reduced expenditures on gasoline. Third, the installation of additional fuel economy technologies by automakers increases the average price of new vehicles (although those receiving a rebate would still pay less than before). Fourth, the increased fuel efficiency offered by manufacturers typically comes at the expense of vehicle performance (represented in the CALCARS model by acceleration and top speed), although this is not always the case.

Status

Feebates were originally proposed by Gordon and Levenson at Lawrence Berkeley Laboratory in 1989.[3] This proposal was termed "DRIVE+" (Demand based Reduction In Vehicle Emissions plus reductions in carbon dioxide) and was developed for possible use in the state of California. Legislation based on the DRIVE+ proposal (and going by the same name) was introduced in the California legislature in 1990. Both houses passed the bill but it was vetoed by then-Governor

Deukmejian. It has been reintroduced several times since then but has never become law. The DRIVE+ proposal was based on tailpipe emissions and emissions of carbon dioxide.

Several versions of feebates have also been proposed at the federal level. This continued interest seems to be based on the twin notions that as a market-based policy, feebates can reduce gasoline demand with a minimum amount of economic distortion, and that the revenue neutrality capability of feebates make such proposals more palatable politically than other more costly programs with similar aims.

The revenue neutrality of feebates has political and administrative appeal. However, it is obvious that some consumers would lose and some would gain economically. In contrast to the government revenue neutrality, the net of the losses and gains by consumers may not be equal to zero.

Assumptions

The Commission's CALCARS model was used to simulate these options. CALCARS is a behaviorally-based vehicle choice, usage, and demand model estimated specifically for California. The model predicts consumer vehicle choice at the household level, using 57 types of households that vary by annual income, number of members, and number of employed members.

The feebate rate used in this analysis is $30,000 per pound of carbon per mile.[4] As an example, using a carbon threshold corresponding to 21 miles per gallon (mpg), the fee for a new light-duty vehicle (LDV) with an efficiency of 15 mpg would be around $3,500, while the rebate paid the to purchaser of a 30-mpg LDV would be roughly $2,600. The threshold level in each year resulted from an iteration process that continued until revenue neutrality was achieved.

This analysis looks at feebates under two scenarios. Case 1 assumes a State feebate with a limited response by automakers, as described in the following section. Case 2 assumes a nationwide system where manufacturers are induced to add fuel economy technologies to almost all models. In a sense, these two cases serve to "bound" the impacts of feebates.

In this analysis the staff assumes that there is some response by auto manufacturers to the feebate. In other words, manufacturers are induced to increase the fuel efficiency of at least some models, as the feebate makes this a more profitable strategy.[5] This response is much more pronounced in the nationwide feebate case, where almost all models are affected, than in the state feebate case.

For Case 1 (state feebate), manufacturers were assumed to install additional fuel economy technologies for models whose sales in California exceeded 20,000 in 2001.[6] For these models, technologies were added in the same manner as in the nationwide case (see below). In the CALCARS simulation, which predicts ownership at the size class level, vehicle class characteristics (e.g., fuel efficiency, acceleration) were then changed from those in the base case, based on the proportion of sales in that class attributable to such models.[7]

For Case 2 (nationwide feebate), vehicle manufacturers were assumed to install additional fuel economy technologies as long as the cost of these technologies was less than the change in the feebate resulting from these additions. These changes in vehicle attributes were projected from analysis performed by K.G. Duleep (EEA, Inc.) for a nationwide feebate scenario. The methodology used by Duleep also allowed manufacturers to trade excess credits.

The staff assumed that feebates affect personal vehicle decisions only because the models used by the Commission for commercial fleet and freight energy demand are currently not behaviorally based. Although travel by light-duty commercial vehicles is unaffected, gasoline demand for these vehicles is reduced due to installation of additional fuel economy technologies by auto manufacturers.

Results

Tables 3D-1 and 3D-2 display the results for gasoline reduction from a state feebate (Case 1). Of the two cases, nationwide feebates appear to yield the highest direct benefits for California; however, state feebates also appear promising (although net direct benefits are slightly negative in the first few years of the simulation) if manufacturers respond in a limited fashion as assumed for Case 1. More detailed results and discussions are located in Attachments A and B.

Table 3D-1. Gasoline Reduction from State Feebate (Case 1)

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	389	1,023	1,429
Reduction From Base Case Demand (percent)	2.4	5.5	6.6

Table 3D-2. Direct Non-Environmental Benefits from State Feebate (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	254	(335)	(81)
2002-2020	3,253	(1,376)	1,877
2002-2030	8,565	(2,485)	6,080
*Negative values are enclosed in parentheses.			

Tables 3D-3 and 3D-4 display the results for gasoline reduction from a nationwide feebate (Case 2). Among the Pricing Options considered (Group 3), a nationwide feebate system that can influence consumer choice of vehicles results in the largest estimated reduction in gasoline demand, nearly 20 percent of the projected base case demand by 2030. A nationwide feebate is estimated to achieve California net savings similar in magnitude to the best vehicle fuel economy cases. More detailed results and discussions are located in Attachments A and B.

Table 3D-3. Gasoline Reduction from Nationwide Feebate (Case 2)

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	979	2,929	4,259
Reduction From Base Case Demand (percent)	6.0	15.7	19.7

Table 3D-4. Direct Non-Environmental Benefits from Nationwide Feebate (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	B	C (A+B)
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	2,081	(808)	1,273
2002-2020	14,759	(3,814)	10,945
2002-2030	34,146	(7,246)	26,900
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- Given the assumptions made in this analysis, the impacts of a feebate system, both in terms of the reduction in gasoline demand and on the benefits to California vehicle owners, depend heavily on the degree to which auto manufacturers respond. In fact, without any manufacturer response, net consumer benefits may be negative over all time periods, due to the deadweight loss.[8] Therefore, any feebate plan must carefully consider the reaction of automakers.[9]

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[1] There may well be effects not captured here; for example, vehicle weight reductions. In providing a revised set of vehicle attributes for this analysis, K.G. Duleep assumed that the feebate induces manufacturers to reduce slightly the weight of some models to improve fuel efficiency, and weight is not included as a vehicle characteristic in CALCARS. Therefore, to the extent that vehicle owners value weight as an attribute (as a perceived indicator of vehicle safety), the estimated net benefits of a feebate may be overstated. As another example, manufacturer efforts to improve fuel economy may involve the use of composite materials that can potentially prolong the life of a vehicle.

[2] Those who switch from a high-carbon to a low-carbon vehicle will not benefit by the full amount of the rebate, because the value to these buyers of the high-carbon vehicle was higher than that of the low-carbon vehicle before the feebate was implemented (see the discussion on the net costs of vehicle incentives in the appendix). In other words, the average buyer who switches to the low-carbon vehicle reaps a benefit less than the amount lost by the high-carbon buyer who provided the rebate. All else equal, when the losses and gains are summed over all new vehicle buyers, the net impact on benefits is negative.

[3] Gordon, D., and L. Levinson, *DRIVE+: A Proposal for California to use Consumer Fees and Rebates to Reduce New Motor Vehicle Emissions and Fuel Consumption*, Lawrence Berkeley Laboratory, Berkeley, CA, 1989.

[4] $30,000 is a somewhat arbitrary figure, high enough to have a significant effect on vehicle prices and therefore vehicle purchases. It was used in a previous study by Commission staff that compared the effects of a carbon tax and a feebate that were designed to yield the same reduction in gasoline demand *(A Comparison of Statewide Policies to Reduce Carbon Emissions by Personal Cars and Light-Duty Trucks in California: Carbon Taxes vs. Feebates*, October, 1996).

[5] When the addition of a technology to improve fuel efficiency costs less to a manufacturer than the resulting impact on the feebate, the manufacturer can increase profits by adding the technology.

[6] According to K.G. Duleep, if sales of a particular model exceed 20,000 vehicles in a certain area, the manufacturer would likely find it profitable to add fuel economy technologies if faced with a feebate, thus providing a "California version" of the model.

[7] For example, if 50 percent of the sales in a particular class were attributable to models selling more than 20,000 units in 2001, the appropriate vehicle characteristics were changed in each year to the base case values plus 50 percent of the difference between the base case attributes and the national feebate case attributes. The percentage of vehicles in a given class attributable to these models ranged from zero (various classes) to over 80 (the standard pickup class).

[8] This result was indeed found in a previous analysis of feebates (*A Comparison of Statewide Policies to Reduce Carbon Emissions by Personal Cars and Light-Duty Trucks in California: Carbon Taxes vs. Feebates*, CEC Staff Report, October 1996).

[9] It should be acknowledged here that any analysis (including the work of K.G. Duleep) designed to estimate the response by automakers to a nationwide feebate, and the cost and effectiveness of installing additional fuel economy technologies, requires engineering and economic judgement, particularly in predicting the impact of combining technologies.

Option 3E
Registration Fee Transfer

Description

This option would transfer a portion of annual auto registration fees in California (for 2003-2030) to a marginal cost through a gasoline surcharge.

Background

Economic efficiency and consumer welfare can be improved if the cost of providing a service can be more closely tied to the actual users of that service. A portion of annual auto registration fees is directed toward transportation uses for which actual costs depend on the amount of driving in the state. Benefits may be realized, therefore, by converting this portion to a marginal cost for drivers through a fuel surcharge. This surcharge would mean that those that drive more, all else equal, would pay more toward funding our transportation system, while those that drive less would pay less.

Because a registration fee transfer would increase the marginal cost of driving through the fuel surcharge, VMT and gasoline use should decrease. The transfer acts as a travel demand measure, therefore, and external costs related to both driving (e.g., congestion) and gasoline use (e.g., global warming) would be expected to fall. An advantage of a transfer relative to other measures (such as a VMT tax) is that private costs for the average motorist may be reduced.

Using a VMT tax for this transfer would be more efficient in an economic sense, since motorists would be charged directly for road use. A gasoline surcharge is less direct, since owners of higher efficiency vehicles would pay less, all else equal, than owners of vehicles with lower fuel economy. A fuel surcharge is therefore a "second best" solution. The purpose of this analysis, however, is to examine measures to reduce petroleum dependency, and the reduction in gasoline demand should be greater if a gasoline surcharge were used for the transfer.[1] In addition, employing the fuel surcharge provides a convenient collection mechanism.

Status

Many states allocate state gasoline tax funds toward highway service and maintenance.

Assumptions

The Commission's CALCARS model was used to simulate this option. CALCARS is a behaviorally-based vehicle choice, usage, and demand model estimated specifically for California. The model predicts at the household level, using 57 types of households that vary by annual income, number of members, and number of employed members.

In this analysis, a portion ($50) of current registration fees is converted into a fuel surcharge. Fifty dollars was roughly the amount of fees per average vehicle directed toward the California

Highway Patrol and state highway maintenance in 2000.[2] This portion is equal to 0.4 cents per mile (assuming average annual mileage of 12,000). To collect this amount per mile required a fuel surcharge of slightly less than 10 cents per gallon. For this option, therefore, vehicle owners would pay $50 less per year in registration fees while paying an increase in the cost of gasoline of around ten cents per gallon.

Note that the critical assumption that must be made is that the cost of the Highway Patrol and of state highway construction and maintenance is proportional to vehicle miles traveled.

The registration fee transfer was assumed to affect personal vehicles only, as the models used by the Commission for commercial fleet and freight energy demand are currently not behaviorally based.

Results

Table 3E-1 displays the results for gasoline reduction from a registration fee transfer. Similar to the gasoline tax analysis, annual reductions in gasoline demand relative to the base case increase over time as motorists switch to more efficient vehicle to reduce exposure to higher fuel costs (although the effect is much slighter in this case). Percentage reductions in VMT (not shown) are smaller than reductions in gasoline demand, reflecting the incentive to purchase vehicles with higher fuel efficiency created by higher gasoline prices.[3] More detailed results and discussions are located in Attachments A and B.

Table 3E-1. Gasoline Reduction from Registration Fee Transfer

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	120	147	174
Reduction From Base Case Demand (percent)	0.7	0.8	0.8

Table 3E-2 shows the net-benefit results for consumers and the impact on government revenues in present value terms, for 2010, 2020, and 2030. These calculations are net amounts relative to the base case forecast.

Table 3E-2. Direct Non-Environmental Benefits from Registration Fee Transfer (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	21	(180)	(159)
2002-2020	40	(370)	(330)
2002-2030	54	(511)	(457)
*Negative values are enclosed in parentheses.			

The gain in economic efficiency that would be predicted by theory is reflected in the positive net benefits for consumers shown in the table. These benefits are a net of the reduction in direct payments for registration fees and the burden of higher fuel costs. Effectively, the average motorist now incorporates highway costs in his marginal driving decisions and is able to reduce his total costs by driving less—an option not available with conventional vehicle registration.

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- The responsiveness of motorists to higher fuel prices will determine the magnitude of net consumer benefits. The more responsive are drivers, the higher the level of net consumer benefits (and the higher the reduction in VMT and gasoline use). However, consumer net benefits will always be positive, given the assumptions made here (they would be zero if there were absolutely no response to higher fuel costs). That is, the average consumer will always be better off. Of course, this does not mean that every motorist would be better off. Those who drive many more miles than the average could end up with a higher total cost of driving, and drivers of vehicles with very low fuel efficiency could be adversely affected, unless a mechanism were implemented to address differences in fuel efficiency.

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[1] This is so because a gasoline surcharge increases the incentive to purchase a vehicle with high fuel efficiency.

[2] *Fast Facts*, Department of Motor Vehicles, 2001.

[3] This result represents a rebound effect. The switch to more efficient vehicles reduces the impact of higher gasoline prices on vehicle fuel cost per mile.

Option 3F
Purchase Incentives for Efficient Vehicles

Description

This option involves government providing a purchase incentive for the most fuel-efficient vehicles in each class at the time of sale to reduce the purchase price and thus, increase the relative value of fuel-efficient vehicles compared to average fuel economy vehicles.

Background

Incentives are provided to consumers to encourage the purchase of specific products. Consumer incentives can be provided in the form of tax credits or deductions, rebates and the related fee-bates, or cash incentives directly to the consumer at the time of purchase, or to the manufacturer before the sale.

Direct consumer incentives are a means to increase the market share of fuel-efficient vehicle technologies. The direct consumer incentive approach, unlike a tax credit, is not dependent on the income of the purchaser. The incentive can be obtained even if the purchaser does not have any taxable income. These various forms of incentives have at least one commonality – the funding source is tax based and as such they reduce or return taxes paid by consumers.

From case studies performed using the CALCARS model to estimate the demand for transportation fuels, the staff has found that the model projects at least a 10 percent increase in vehicle sales by vehicle class when the vehicle's purchase price is reduced by 10 percent. Thus, if a consumer is provided a monetary incentive for the purchase of best-in-class fuel economy vehicles, the number of more highly fuel-efficient vehicles sold can be increased beyond the level predicted under the base case demand analysis. The amount of reduced fuel consumption can then be estimated using the purchase price and sales rate relationship predicted by the CALCARS model.

The best fuel-efficient vehicles currently available on the market have the potential to reduce California's gasoline demand by up to 3 billion gallons per year. This level of fuel savings would be achieved if all vehicles purchased each year had the same fuel economy as the "best-in-class" vehicle in terms of fuel economy.

Status

The average vehicle mileage calculated from passenger cars and light-duty truck models in the U.S. DOE *Fuel Economy Guide for Model Year 2002* is 21.5 miles per gallon gasoline.[1] From the same reference, the most efficient vehicle in each vehicle class is approximately 28 percent more efficient that the average of all vehicles available. If consumers purchased the most efficient vehicles in each class, the average fuel economy of vehicles operating in California would eventually increase from approximately 21.5 to 28 miles per gallon.

Today, about 1.5 million new light-duty vehicles are sold annually in California. Approximately 30 percent of these vehicles (441,000) can be categorized with best-in-class fuel economy performance.[2]

Assumptions

Assuming an incentive program could increase the rate of purchase of the most fuel-efficient vehicles, this scenario assumes that a 10 percent purchase incentive for best-in-class vehicles would increase annual sales of such vehicles by 10 percent.

The scenario in this analysis begins in 2003 with incentives being provided to increase the sale of best-in-class fuel economy vehicles. The incentive results in an annual best-in-class fleet population that is 10 percent larger than the new annual population under base case conditions, growing by 2 percent every model year.

At the current fleet growth rate of 2 percent per year as calculated from Department of Motor Vehicle registration data, staff calculates that with an increase in efficient vehicles purchases of 10 percent beginning in 2003, approximately one million additional vehicles would be achieving this higher fuel economy by 2030.[3]

Using manufacturer's suggested retail prices for vehicle prices, the staff calculated the average price for the most efficient vehicle in class to be about $19,000.[4] This is $2,400 less than the average vehicle price. The staff assumed, however, that the potential reduced vehicle cost of a best-in-class vehicle is a dollar-for-dollar reduced benefit to the consumer (i.e., between two choices, the consumer would not buy a more expensive vehicle unless the vehicle provided greater benefits than the other choice). Thus, this potential dollar savings is not considered a benefit in the economic comparison performed for this analysis.

The staff assumed that to achieve the 10 percent growth in the sale of best-in-class vehicles, a consumer would need a $1,900 incentive in order to purchase the more efficient vehicle in lieu of the average vehicle in class. The incentive amount is 10 percent of the average manufacturer's suggested retail price for best-in-class vehicle models. This amount makes the consumer feel better off when purchasing the vehicle, even though it might cause the loss of non-monetary benefits provided by another vehicle that would otherwise have been purchased. For some consumers, nearly the full incentive could be considered a benefit. However, others may view the incentive amount as being just enough to overcome the loss of benefits provided by the other vehicle being considered. On average, the consumer benefit derived from the incentive is assumed to be one-half of the incentive amount.

Results

Table 3F-1 displays the results for gasoline reduction from purchase incentives for efficient vehicles. The option has a potential to reduce 2030 gasoline demand by about 0.6 percent. More detailed results and discussions are located in Attachments A and B.

Table 3F-1. Gasoline Reduction from Purchase Incentives for Efficient Vehicles

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	50	107	131
Reduction From Base Case Demand (percent)	0.3	0.5	0.6

The economic comparisons of this option against the base case conditions are shown in Table 3F-2. The direct consumer benefits can be relatively large since each consumer purchasing a best-in-class fuel economy vehicle will receive an incentive. The individual consumer benefit value for the incentive is $950 or $1,900. Free riders receive the larger benefit (see the discussion in Attachment A for additional detail on economic comparisons). The change in government revenue reflects the total amount of funds expended for the incentives combined with reduced fuel excise taxes. The direct net benefit is always negative due to the deadweight loss impact of the incentive.

Table 3F-2. Direct Non-Environmental Benefits from Purchase Incentives for Efficient Vehicles (present values, 2002 base year, 2001$, $1.64/gallon gasoline)*

	A	**B**	**C (A+B)**
Present Value Period	**Direct Non-Environmental Consumer Benefits (million $)**	**Change in Government Revenue (million $)**	**Direct Non-Environmental Net Benefits (million $)**
2002-2010	6,315	(6,672)	(357)
2002-2020	12,404	(13,197)	(793)
2002-2030	16,961	(18,098)	(1,138)
*Negative values are enclosed in parentheses.			

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- There is uncertainty in the number of people who would have purchased the best-in-class efficient vehicle without the incentive or a smaller incentive.

- There is uncertainty in the number of people who will change their purchase habit for the incentive proposed.

- There is uncertainty in the projected fuel savings for each vehicle class in future years as the fuel savings is directly affected by the fuel economy of the vehicle models offered and by the fuel economy of the vehicle that was being considered instead of the best-in-class vehicle. Although the staff assumed that the consumer influenced by the incentive would normally have purchased an average fuel economy vehicle from the same class, the consumer taking the incentive may have been considering a vehicle with a fuel economy level above the average but slightly below the best-in-class level. The fuel reduction in this case would be less than predicted in the analysis since the difference in fuel economy is not as large. Another possible outcome involves the consumer taking the incentive to buy a different class of vehicle (one that was still best-in-class) that had a lower fuel economy than the class considered in the base case. In this latter case, the fuel consumption would not decrease, but increase. However, an incentive program could be designed to limit these types of events.

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[1] U.S. Department of Energy, *Model Year 2002 Fuel Economy Guide*, [www.fueleconomy.gov/feg/feg2000.htm].

[2] California Department of Motor Vehicles, Vehicle Registration (VR) Data Base, California Energy commission VR Processing Methodology, 04-01-02 run date, Gary Occhiuzzo.

[3]Ibid.

[4] *New Vehicle Pricing*, [www.edmunds.com/new/index/index.html].

GROUP 4
OTHER OPTIONS

Option 4A
Expanded Use of Public Transit

Description

In this option the staff examines the impact of expanded use of transit on vehicle miles traveled and petroleum use.

Background

Transit accounts for about 1 percent of the passenger miles of travel in the state.[1] Buses support about two-thirds of transit travel with light and heavy rail providing the remainder. Transit serves as a reasonably energy efficient mode of travel. With an average of about 10 passengers per vehicle, buses achieve nearly 40 passenger miles per equivalent gallon of diesel fuel. Rail averages about 3 passenger miles per kilowatt hour. Delucchi estimates the social costs per passenger mile of transit are likely several times the comparable costs for autos.[2] The government subsidies required for operating and capital costs account for most of this cost.

In addition to reducing petroleum demand, expanded use of transit helps reduce auto use and congestion. Analysis by the NRDC shows household auto use strongly depends on access to transit and housing density.[3] Testimony by the Planning and Conservation League (PCL) noted that a recent study found that in a transit-oriented neighborhood people walked, biked, and took public transit for 40 percent of daily trips, as opposed to less than 15 percent for the general region.[4]

Status

The PCL has proposed the Traffic Congestion Relief Act that would allocate 30 percent of the state share of the sales tax on new and used cars and trucks to a new trust fund for transportation improvements around the state. Dedicated programs in the Act would include building new light rail and bus services to reduce traffic congestion in every region and provide operating funds for transit.

The transit portion of passenger miles traveled in the state today is about 30 percent less than in 1980. Although since 1980 ridership on rail transit has increased, bus transit accounts for about 70 percent of the transit ridership and bus ridership has stayed nearly constant during the last 20 years.[5]

Assumptions

A scenario consisting of a series of programs to increase transit use from 1 percent to 2 percent of passenger travel in the state by 2020 was examined. The staff assumed rail or natural gas buses provided the additional transit service. This scenario would require transit ridership to grow at an average annual rate of 5.4 percent. Based upon 1.6 passengers per light-duty vehicle mile, 1 percent of passenger travel equals 4 billion vehicle miles or 6.4 billion passenger-miles.[6]

This travel would require 192 million gallons of gasoline using vehicles with an average fuel economy of 21 miles per gallon (base case forecast).

The same average growth rate of 5.4 percent in transit ridership through 2030 would increase transit use to 2.8 percent of passenger travel and save 411 million gallons of gasoline. As various transportation factors such as mitigating congestion dominate the development of transit, the staff has not identified any particular transit expansion or the associated project costs.

Results

Table 4A-1 displays the results for gasoline reduction from expanded use of public transit. Increased transit use would reduce growth in vehicle miles traveled and petroleum use. Due to the complexity involved in performing a site-specific, transit property analysis, a generic attempt at estimating is not possible. No attempt was made, therefore, to calculate direct net benefits.

Table 4A-1. Gasoline Reduction from Expanded Use of Public Transit

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	N/A	192	411
Reduction From Base Case Demand (percent)	N/A	0.8	1.5

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- Appropriate land use planning to enhance transit use.
- Adequate availability of funds to enhance transit service.
- Cost-effectiveness of enhanced transit to reduce petroleum use.

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[1] Federal Transit Administration, 1999 National Transit Database, 1999.

[2] Delucchi, Mark, *Should We Try to Get the Prices Right?* ACCESS, University of California Transportation Center, Berkeley, CA, Spring 2000.

[3] Liu, Donna, Natural Resources Defense Council, CEC Workshop, September 18, 2001.

[4] Spelliscy, Sandra, Planning and Conservation League, CEC Workshop, September 18, 2001.

[5] California Department of Transportation, *Travel and Related Factors in California*, Annual Summary 1981 and 1998.

[6] Federal Highway Administration, *Summary of Travel Trends 1995 Nationwide Personal Transportation Survey*, December 1999.

Option 4B
Land Use Planning

Description

Housing density, job-housing balance and other land use factors affect vehicle miles traveled (VMT) and transportation energy use. In this option the staff examines the enactment of policy to provide guidance and economic incentives to achieve improved land use to reduce VMT growth.

Background

Based on analysis by Parsons Brinckerhoff, California could reduce statewide transportation energy consumption by 3-10 percent with the implementation of Smart Growth policies across the state.[1] The estimates are extrapolated from Smart Growth travel modeling efforts in five California regions: Los Angeles (Western Riverside County only), San Francisco, San Diego, Sacramento and Monterey. The estimates reflect four Smart Growth Actions as follows:

- City and transit station-focused land use development
- Increases in transit supply
- Market pricing (parking fees)
- Improvements to regional job-housing balance

VMT has a direct correlation with transportation energy consumption. Smart Growth VMT savings for city-centered land use development ranged from: 0.2 percent (Riverside) to 11 percent (Sacramento) and 12.2 percent (Monterey). Scenarios for transit station-focused development typically combined with some level of increased transit supply, reducing VMT by 1.7 percent (Riverside) to 13.0 percent (San Diego). San Francisco (MTC) runs implied market pricing leads to a 0.8 percent travel reduction. Improvement of jobs-housing balance in Riverside (28 percent increase in jobs/household ratio) leads to a 1.6 percent reduction in daily travel.

Status

California has several opportunities to assist regional and local entities in educating the populace and facilitating sustainable Smart Growth choices. For example, the Statewide Coordinating Committee of the Urban Land Institute California Smart Growth Initiative recommends that state leaders consider implementing incentive and regulatory reforms to advance Smart Growth.[2] The recommendations include rewarding communities for integrating Smart Growth practices into planning and development processes, programming transportation funds to promote Smart Growth, authorizing tax-increment financing for transit-oriented development, and revising regulations governing environmental review and local planning to encourage Smart Growth.

Assumptions

Because land use planning is a long-term strategy, Parsons Brinckerhoff developed the estimates of potential energy savings of land use measures only for 2020. The staff assumed only limited additional savings would be achieved by 2010. The estimate of 3 percent transportation energy savings would reduce gasoline demand by 580 million gallons and 10 percent savings would reduce gasoline demand by 1,920 million gallons by 2020.

Results

Table 4B-1 displays the results for gasoline reduction from land use planning. Among this group of options, statewide use of Smart Growth policies provides the largest estimated annual petroleum fuel reduction, about 2.5 percent of base case demand for 2030. As land use measures cause a number of trade-offs for costs and benefits, no attempt was made to calculate direct net benefits.

Table 4B-1. Gasoline Reduction from Land Use Planning

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	N/A	580	680
Reduction From Base Case Demand (percent)	N/A	2.4	2.5

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- Resistance to changing present patterns of urban growth.
- Lack of understanding of advantages of "smart growth".
- Need for enlightened long term planning.

[1] Parsons Brinkerhoff, *California Smart Growth Energy Savings MPO Survey Findings*, September 21, 2001.

[2] Urban Land Institute, *Putting the Pieces Together*, 2002.

Option 4C
Telecommuting

Description

In this option the staff examines telecommuting as a potential strategy for reducing travel and hence congestion and energy consumption.[1] Public agencies could increase case-study information on successful telecommuting programs and increase incentives to increase telecommuting.

Background

Telecommuting appears to have considerable popular appeal, offering employees reduced commuting time and cost while offering employers the potential of improved productivity and savings of facilities costs. On the other hand, a number of barriers prevent telecommuting from achieving the penetration that might be expected. On the employer side, conventional wisdom holds that management resistance to the concept is probably the largest single factor slowing adoption. On the employee side, many workers whose jobs are well-suited to telecommuting and whose managers would permit it, do not choose to telecommute for a variety of reasons and many who start telecommuting, stop within about a year. Nevertheless, data available suggests that nationally about 11 million or 9 percent of the workforce telecommutes at least once a month.

Status

Pat Mokhtarian (UC/Davis) has conducted a study for the Commission to attempt to identify the extent telecommuting reduces vehicle miles traveled (VMT) and energy use.[2] A number of studies have established the short-term transportation benefits of telecommuting at the disaggregate level: vehicle miles traveled are substantially reduced for those who telecommute, for as long as they telecommute. The question is whether telecommuting is likely to provide a substantial contribution to reduce VMT and fuel use. Mokhtarian has suggested it will not in view of the relatively small amounts of telecommuting occurring today, the relatively slow growth that can be expected as the phenomenon matures, as attrition continues to occur and the likelihood of long-term indirect impacts (e.g. longer commutes) partly counteracting the short-term direct savings. In a previous study using a modeling approach, analysis by Mokhtarian suggested telecommuting eliminates at most 1 percent of total household vehicle miles traveled.[3]

Assumptions

The present study by Mokhtarian using national VMT data found appropriate data are quite limited and the results were inconclusive. The amount of the reduction is most likely small, falling somewhere between a 2 percent reduction in VMT and essentially no change in VMT. An additional reduction of light duty fuel use by 0.34 percent could yield fuel savings of 56 million gallons in 2010 and 65 million gallons in 2020. The base case is based on actual fuel use and includes the effects of current levels of telecommuting.

Results

Table 4C-1 displays the results for gasoline reduction from telecommuting. Based on present information, telecommuting appears to offer only very minimal potential to reduce VMT and energy use. Better data are needed for a more precise determination of the true impact of telecommuting on VMT. No attempt was made, therefore, to calculate direct net benefits.

Table 4C-1. Gasoline Reduction from Telecommuting

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	56	65	N/A
Reduction From Base Case Demand (percent)	0.3	0.3	N/A

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- Disseminating case-study information on telecommuting successes may be an effective approach to motivate increased telecommuting.

[1] Telecommuting is salaried employees working at home or a location closer to home than the regular workplace, using information and communication technology to support productivity and communication with other workers and clients.

[2] Pat Mokhtarian, *Impacts of the Telecommuting on Vehicle-Miles Traveled: A Nationwide Time Series Analysis*. UC Davis, December, 2001.

[3] Pat Mokhtarian, *A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel*, Urban Studies, Vol. 35, No.2, 215-241, 1998.

Option 4D
Reducing Speed Limits

Description

As vehicles are less efficient at high speeds, enforcing reduced speed limits on state highways could reduce petroleum use. Appropriate action would need to be taken by the Governor or Legislature to implement this change.

Background

Increased California Highway Patrol enforcement would require increased spending authorization. Funding and resources would be required for new signage where the current speed limit exceeds 65 miles per hour (mph) or higher, as well as to notify motorists of the increased enforcement activity.

Status

Little data are available for speed distributions on California highways. Data for average speeds in the Los Angeles region suggest 8.9 percent of the vehicle miles traveled occurs at speeds from 57.5 to 62.5 mph and 13 percent at speeds from 62.5 to 67.5 mph.[1] Higher average speeds accounted for no additional vehicle miles traveled. Data from the Federal Highway Administration for 1988-1997 cars and light trucks show fuel economy declines by 3.1 percent going from 55 to 60 mph and 9.9 percent from 55 to 65 mph.[2]

Assumptions

Costs of the measure would include modification of speed limit signs and enforcement of speed limit. Contingency planning analysis determined the program could be self-funding as penalty fees received from ticketed motorists would offset government costs of the program.[3] Other direct costs would include time losses due to slower driving.

Results

Reducing the speed limit in California to 55 mph could result in potential fuel savings of 1.2 percent as shown in Table 4D-1. Not enough data existed to estimate costs and the likely consumer response to a change in speed limits or more aggressive enforcement. No attempt was made, therefore, to calculate direct net benefits.

Table 4D-1. Gasoline Reduction from Reducing Speed Limits

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	258	294	335
Reduction From Base Case Demand (percent)	1.2	1.2	1.2

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- Public acceptance is key to making speed limit strategy work.[4] There is currently probably little support for reduced speed limits.

- Present amount of travel at speeds above 70 mph that substantially affects fuel economy.

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[1] *Year 2000 Light and Medium Duty VMT by Speed Distribution*, SCAG 2001 AQMP/2001 RTP, data received by ARB 7-19-01.

[2] Oak Ridge National Laboratory, Transportation *Energy Data Book*, Edition 20, October 2000, p 7-23.

[3] California Energy Commission, *Energy Shortage Contingency Plan*, Technical Appendix, March 1993, p T-24.

[4] National Research Council, Transportation Research Board Special Report 204: 55, *A Decade of Experience*, 1984.

Option 4E
Voluntary Accelerated Vehicle Retirement

Description

Voluntary Accelerated Vehicle Retirement (VAVR) programs provide incentives to scrap older light-duty vehicles that are responsible for high levels of emissions. In this option the staff examines the energy benefits that could be achieved from a VAVR program.

Background

As the vehicle exhaust standards for criteria air pollutant emissions have become much more stringent and some older vehicles are extremely high-emitters of criteria pollutants, VAVR programs can contribute substantially to reducing criteria pollutant emissions. The change in fuel use would depend on the change in the ratio of vehicle miles traveled (VMT) divided by miles per gallon (mpg).

EPA data indicate the average on-road fuel economy of light duty vehicles over the last 20 model years has been in the range of 20 to 22 mpg.[1] Commission analysis estimates the fleet average fuel economy of all light duty vehicles in California to be in this range with a value of 20.8 mpg.[2] DMV registration data suggest about 85 percent of the vehicles in the fleet are 20 years of age or less. The older vehicles average about 15 mpg.

In their analyses of the effect of VAVR programs in Southern California, both Sierra[3] and RAND[4] assumed the total number of miles traveled would not be altered by the VAVR program and the scrapped vehicles are replaced, on average, by the average vehicle remaining in the fleet. These assumptions would result in no change in energy use when scrapping vehicles less than 20 years old. With reduced use of vehicles over 20 years old, perhaps 6,000 miles per year, scrapping one of these vehicles today would save about 100 gallons of fuel annually.

Status

Using the CALCARS vehicle choice model to analyze the effects of VAVR programs starting in 1999 for 75,000 vehicles annually in Southern California, the staff forecast a scrappage program would cause a slight increase, perhaps 0.5 percent, in gasoline use.[5] Although the model predicts the replacement vehicle would be slightly more efficient, the increase in fuel efficiency would not be enough to overcome the positive effect on VMT from a younger fleet, so gasoline use would increase.

As one example of the effect of a VAVR program, analysis of the 1990 Unocal program in the South Coast found 86 percent of the participants in the program were driving another vehicle.[6] In addition, 68 percent of the new cars had higher fuel economy and 82 percent of the cars were driven the same or more miles per day than the cars they replaced. Data suggested a typical retired car had an average remaining life of 6 years.

Assumptions

The staff assumed accelerated scrappage of 150,000 vehicles annually statewide. Relying on the approach of RAND and Sierra using constant VMT, staff assumed in 2010, 10 percent of the VAVR retirements would be cars older than 1980 vintage. The staff also assumed the program would accelerate retirements by 6 years. Using the above value of 100 gallons of annual fuel savings per retirement of pre-1980 vehicles, 8 million gallons are saved in 2010. The staff assumed little activity for a VAVR program by 2020 as most cars would have on-board diagnostic (OBD) systems. All 1996 and newer car vehicles are equipped with OBD systems to ensure that the vehicle remains as clean as possible over its entire life.

In the other approach the staff relied on the CALCARS results, where VMT would increase about 0.5 percent statewide based on some replacement of retired cars by newer cars which are driven more as predicted by the model. With little or no difference in fuel economy, especially for post-1980 vehicles, between the retired and replacement vehicles, gasoline demand would also increase 0.5 percent, or a 0.4 percent increase in total gasoline and diesel demand.

The energy portion of the VAVR program has no cost as the program is being conducted and incentives are being given primarily for emission reductions.

Results

Table 4E-1 displays the results of the analysis on VAVR programs. This option results in growth in gasoline consumption, since a newer replacement vehicle tends to be driven more than an older vehicle that is scrapped. No attempt was made, therefore, to calculate direct net benefits.

Table 4E-1. Gasoline Reduction from Voluntary Accelerated Vehicle Retirement

	Year		
	2010	**2020**	**2030**
Annual Reduction (millions of gallons)	9 to –86	N/A	N/A
Reduction From Base Case Demand (percent)	0 to –0.4	N/A	N/A

Key Drivers and Uncertainties

The key uncertainties in this analysis involve the following:

- Appropriate incentives.
- Change in VMT.

[1] U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends 1975 Through 2001*, September 2001.

[2] California Energy Commission Staff Draft Report*, Base Case Forecast of California Transportation Energy Demand*, December 2001.

[3] Sierra Research, *Vehicle Scrappage: An Alternative to More Stringent New Vehicle Standards in California*, March 15, 1995.

[4] RAND, *Fighting Air Pollution In Southern California by Scrapping Old Vehicles*.

[5] California Energy Commission, Preliminary Staff Draft, *Comparing the Effects of Two Accelerated Vehicle Retirement Programs Using a Behaviorally-Based Vehicle Choice Model*, November 26, 1996.

[6] Fairbank, Bregman & Maullin*, Final Summary Report on the Results of the Unocal Scrap Program Post-Participation Survey*, March 22, 1991.

Option 4F
Ridesharing

Description

In this option the staff examines increased ridesharing as a strategy to reduce petroleum use. Ridesharing is a combination of transportation demand management measures that improve travel through the more efficient use of the existing transportation system.[1]

Background

The 1995 National Personal Transportation Survey indicates commuting accounts for 31 percent of household VMT.[2] Driving alone is the predominant mode for commuters. The Census 2000 found 71.8 percent of commuters in California drove alone. The 2000 Sacramento Household Travel Survey[3] estimated 80.9 percent and the 2001 San Francisco Bay Area Commute Patterns Survey[4] estimated 69 percent drove alone. The Census 2000 found 14.5 percent of commuters used carpools and vanpools in California. The Sacramento Survey indicated 9.7 percent of the commuters travel in carpools and vanpools with about 17 percent from the Bay Area survey.

As household travel accounts for about 83 percent of California light duty vehicle VMT, commuting accounts for about 26 percent of gasoline use. Present levels of carpool and vanpool use reduce California gasoline use by about 3 percent. Thus a small change in carpool and vanpool use will have a relatively small impact on fuel use.

Status

The relative amount of carpooling and vanpooling appears to have changed little over the last decade. The census found 14.6 percent of commuters used carpooling and vanpooling in 1990 in California as compared to 14.5 percent in 2000. The survey data show carpooling varying in the range from 16 to 19 percent of commuting trips over the period from 1993 to 2001 in the Bay Area.

Ridesharing programs have achieved relatively low cost travel reduction for a limited number of commuters. A recent report identifies about 5,000 daily trips reduced, annual equivalent to about 0.05 percent of total VMT, in Los Angeles County from participants in the FY 2000/2001 rideshare program at a cost of $0.13/mile reduced for carpools and $0.01/mile reduced for vanpools.[5] In the Regional RideLink Program, new ride sharers eliminated 44 million annual VMT or equivalent to about 0.2 percent of the VMT in the San Diego region during FY 1999.[6] San Diego funds the RideLink program because it is a low-cost method of providing travel choices to commuters. With the amount of carpooling staying relatively unchanged, the ridesharing programs appear to have helped replace those lost to drive alone and maintain the percentage of commuters using carpooling and vanpooling.

Assumptions

While present results suggest incentives and other marketing programs will increase ridesharing, the specific potential and cost effectiveness for expansion of ridesharing programs is unclear. As identified above, California census data and Bay Area survey data show a relative constant percentage of carpooling and vanpooling as a part of commuting. The 2001 Regional Transportation Plan for Southern California calls for the region to maintain the existing carpool share of commuting. This may require annually perhaps 20 percent more new rideshare participants for Los Angeles County than the level for 2000/2001 discussed above.[7] The present level of the Los Angeles rideshare program with the cost per mile reduced of $0.13 for car pools and $0.01 for vanpools was found to be relatively cost-effective compared to other ridesharing programs.[8] Programs to attract higher numbers of participants to increase the percentage of carpooling and vanpooling would likely come at higher cost.

The relatively stable rideshare programs of Sacramento, San Diego and San Francisco also suggest larger programs are not viewed as cost effective with present conditions. The appropriate criterion for cost-effective programs may be significantly higher than the above cost per mile value for carpools for Los Angeles. Federal Highway Administration analysis showed the marginal costs of high-volume peak congestion to be $0.22 per vehicle mile on an urban interstate.[9] For a 20-mile round trip commute, this value suggests annual savings in social costs due to reduced congestion of over $1,000 for an additional carpool participant.

Results

Options involving personal consumer choice and community choice, such as ridesharing, can potentially achieve reductions in travel and fuel use. If these options are to achieve their potential, however, they must overcome strong preferences for personal mobility, convenience, open space, specific property and personal status. Not enough data existed to complete this analysis. No attempt was made, therefore, to calculate direct net benefits.

Key Drivers and Uncertainties

With the uncertainty in response and cost to achieve higher participation in ridesharing, the staff did not attempt to analyze ridesharing programs beyond the present levels which are included in the base case forecast.

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[1] Ridesharing is a commute alternative to driving alone that includes carpooling and vanpooling. Ridesharing may also include increased transit and telecommuting uses that are addressed as separate measures (Options 4A and 4C) in this report. Ridesharing programs are directed by local agencies.

[2] *Summary of Travel Trends 1995 Nationwide Personal Transportation Survey*, Federal Highway Administration, December 1999.

[3] *Pre-Census Travel Behavior Report Analysis of the 2000 SACOG Household Travel Survey*, Sacramento Area Council of Governments, p. 29, July 25,2001.

[4] *Commute Profile 2001*, RIDES for Bay Area Commuters, Inc., September 2001.

[5] *Policy Recommendations, Rideshare Evaluation Project*, LDA Consulting, April 18,2002.

[6] *2020 Regional Transportation Plan*, San Diego Association of Governments, p. 259, April 2000.

[7] *Policy Recommendations, Rideshare Evaluation Project*, p vii.

[8] *Policy Recommendations, Rideshare Evaluation Project*, p 14.

[9] *1997 Federal Highway Cost Allocation Study*, Federal Highway Administration.